FOUNDRY TRADE JOURNAL
Established 1902
WITH WHICH IS INCORPORATED THE IRON AND STEEL TRADES JOURNAL

Vol. 85 Thursday, September 2, 1948 No. 1670

49, Wellington Street, London, W.C.2
'Grams: "Zacatecas, Rand, London"
'Phone: Temple Bar 3951 (Private Branch Exchange)
PUBLISHED WEEKLY: 26s. per annum (Home and Overseas)

Oxygen Enrichment

The latest development—that of the oxygen enrichment of the blast—in small converter practice is an outstanding example of the wisdom of applying research in order to get the best out of a well-established process. Only too often one sees the lavish expenditure of money, time and effort on some new idea, when a like concentration on the improvement of an existing process would be equally, if not more, profitable. We recollect many thousands of pounds being wasted during the 1914 war on the most elaborate electric melting process imaginable, and this at a time when the young but quite established processes needed research expenditure to an important extent. Now, the outcome of this recent investigation, of which details have recently been published, is not something of a revolutionary character. The main feature is the endowment of the process with an elasticity hitherto not envisaged. This elasticity is consequent upon two main factors:—(1) The speeding up of the process and (2) the higher temperature of the metal. The former may allow of higher output from the existing plant or the use of a smaller vessel for the existing production. It may allow mechanised moulding, where previously it was not practical. It can contribute towards the creation of a reservoir of liquid metal for the making of castings larger than previously possible, especially in conjunction with the second feature of higher casting temperature. This latter, too, has important commercial implications as it may permit the servicing of an additional shop or bay with metal still sufficiently hot for casting up the moulds. This happens to be the *raison d'être* for one installation now being made. In addition, a new field is opened up for the making of alloyed steel castings, as the metal is said to be sufficiently hot for the solution of additions, whilst still preserving sufficient heat for successful casting.

Now that the new process has shown its merits, attention should be turned to see what can be done in the direction of applying the same system to other melting methods. Already it has been stated that an oxygen connection to the cupola blast is advantageous as a stand-by for the removal of a scaffold. Again, one writer in the American Press deems an oxygen supply to the electric furnace to be extremely valuable in cases of emergency. For instance, during the making of stainless steel (carrying, as it does, a very low carbon content), if the bath becomes contaminated with this element, through the breaking of an electrode, then the use of oxygen provides a ready means for its removal. A factor which needs also emphasising in connection with oxygen-enriched air blasts, is the inverse sense. That is, the blast can be regarded as being nitrogen-impoverished. Thus the thermal reactions which take place no longer involve the heating up of four-fifths of volume of gases entering into the system, and higher temperatures and more useful heat from a given fuel consumption should logically follow nitrogen dilution.

On straight economics, the new process probably has little to show. Oxygen costs money, and even though there be a reduction in the quantity of ferro-silicon to be used, there will no doubt be an extra operational cost. Thus, the development is best seen in the light of elasticity conferred such as we have emphasised.

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Education in Lanarkshire

By Our Scottish Correspondent

However fortune may favour the industrial future of Lanarkshire, the Education Committee is determined that one thing the county will continue to produce is good craftsmen. A scheme of apprenticeship and pre-apprenticeship day-time training, inaugurated at Coatbridge Technical School by Dr. Russell in 1942, is to be widened in scope in the immediate future by the opening of two new centres of technical instruction, one of which will be the School of Engineering at Burnbank.

Apprenticeship courses, which necessitate the release from work on one day per week of boys who have begun to serve their time, are at present largely voluntary, and their success depends mainly on the willingness of firms to allow their apprentices to attend. While there are critics of the "learn-while-you-earn" scheme among employers, and while it is recognised that there is some weight behind this criticism, the Education Committee is convinced that the advantages far outweigh the disadvantages, a view which is shared by the majority of employers. So far, co-operation has been excellent.

Pre-apprenticeship courses—which extend over 44 weeks—are for boys leaving school who desire to go into industry. These are full-time day courses up to the London City and Guilds Institutes and National Certificates. Travelling expenses of students living 3 miles or more from the centre are paid, and grants made according to the schemes of the Bursary Department of the Education Committee.

Burnbank School of Engineering, of which Mr. Raymond H. Garner is Principal, opened on Monday (August 30). The School has been excellently equipped and qualified staffs are engaged. Courses have been arranged in moulding and casting for foundry workers, machine shop engineering, and automobile and structural engineering. Courses can also be taken in electrical engineering practice, and radio servicing and communication. There is a workshop for welding and sheet metal work.

The main centre of commercial and industrial education in the county will continue to be the Coatbridge Technical School, which the Education Committee, in co-operation with the Principal, have developed into one of the finest institutions of its kind in the country. Representatives of firms with a special interest in the school or in the engineering classes have a special invitation to call at any time by arrangement with the principal.

Pneumoconiosis and Other Risks

The Industrial Management Bulletin (No. 29) issued by the Council of Ironfoundry Associations contains a very important statement on this subject. It seems that, despite the higher cost to employers of the new National Scheme, there is still need for foundry owners to ensure against certain specific risks. Full details are set out.

British Standards Institution

Austenitic Manganese Steel Castings

The British Standards Institution announce the publication of B.S.1457 for austenitic manganese steel castings for general engineering purposes. The chemical composition and heat-treatment of the steel is specified. Test requirements relate to a hardness test and, where required, a bend test may be called for by the purchaser. Details are included of process of manufacture, fettling and dressing, freedom from defects, testing facilities, branding and repairs to castings. Appendix A gives recommendations with regard to welding procedure. This specification costs 2s., post free.

Methods for the Analysis of Steel

Also announced is B.S.1121, Methods for the Analysis of Steel:—Part 7, Tin in pig-iron, plain carbon steels and certain low-alloy steels; Part 8, Chromium present in small amounts in carbon and low-alloy steels; Part 9, Phosphorus in high chromium-nickel steels; Part 10, Silicon in all types of irons and plain alloy steels other than high tungsten and high tungsten-molybdenum steels, and Part 11, Carbon in steel and low-carbon ferro-chromium. For each method the solutions required, the test procedure and the method of calculation are specified. Price 1s. each, post free.

Copies of these standards can be obtained from the British Standards Institution, 24, Victoria Street, London, S.W.1.

Special Courses at Northampton Polytechnic

Two special evening courses, commencing early in October, are included in the syllabus of the Department of Applied Chemistry at the Northampton Polytechnic. The first is a series of ten lectures at weekly intervals between October 6 and December 8 on "The Technology of Refractory Materials," to be delivered by L. R. Barrett, B.A., B.Sc., M.S. The second consists of lectures on twenty evenings between October 5, 1948, and March 1, 1949, on "The Design and Operation of Fuel-fired Furnaces and Boilers." These latter are divided into five sections and the lecturers are R. A. Acton-Taylor, M.Sc., G. F. J. Murray, B.Sc., and R. F. Hayman, B.Sc.

Enrolment is by personal application at the Polytechnic office, St. John Street, London, E.C.1; the fee for the first course is 12s. 6d. and for the second 21s.

Forty Years Ago

Our issue for September, 1908, reports that the membership of the British Foundrymen's Association was 320, an increase of 70 over the previous year. The total revenue of the "Institute" was £129 4s. 6½d. and the expenditure £96 9s. 1d. The annual meeting was held in Newcastle and Mr. F. J. Cook was elected President. Mr. Pilkington, the retiring president, pleaded for more than one meeting a year. The death was reported of Mr. Harris Tabor, the inventor of the moulding machine bearing his name.

Refractory Materials in the Foundry Industry*

Relations between Constitution, Quality, and Service Life

By G. R. Rigby, Ph.D., and A. T. Green, O.B.E., F.R.I.C.†

General

The foundry industry contains many heating units, each with its own maintenance problems, but in this Paper it is only intended to refer specifically to three of these, the cupola, the ladle and the side-blown converter.

A pre-requisite for the selection of refractory materials is a knowledge of the conditions under which they are expected to give service. A detailed survey of the operating conditions in the cupola and ladle is long overdue, but it is encouraging to note that considerable advance has been made in this direction regarding the side-blown converter, due largely to the activities of the Side-Blown Converter Sub-Committee which has recently published its First Report.[1]

Both in the converter and the cupola, excessive wearing back of the lining takes place only in certain limited areas, so that it is uneconomical to replace the whole lining and recourse is made to patching. A. H. B. Cross[2] has pointed out that the cupola only works on its original lining during the first day's working, in all succeeding heats it is working on the patching materials, at any rate in those areas where excessive wearing back obtains. Thus the actual life of the cupola lining before a complete repair is necessary, is not directly related to the qualities of the original lining material (usually fireclay blocks), but rather to those of the patching materials. With regard to the side-blown converter and the ladle, there appears to be a trend to move away from brick linings towards monolithic rammed linings, using plastic ganister clay mixtures in place of bricks. It is now known that the metal temperature in the side-blown converter varies from about 1,670 deg. C. at the first heat to about 1,750 deg. C. after five or so heats. As this metal is tapped directly into the ladle, the face temperature of the lining of this unit must be of a similar order. Temperatures in the melting zone of the cupola are dependent on the type of burden, being highest (over 1,700 deg. C.) when high percentages of steel scrap are melted. Although face temperatures are extremely high in all three units there must exist through the lining a steep temperature gradient, otherwise it would be impossible to explain the successful results obtained by lining these vessels with refractory materials, the refractoriness value of which is sometimes below the temperature of the hot face. In the case of the side-blown converter, actual measurements of this temperature gradient have been obtained and a drop in temperature of 250 deg. C. was recorded only half-an-inch behind the working face.

Attack by Chemical Corrosion

Examination of the hot face leaves no doubt that chemical corrosion by the slags plays an important part in the wearing back of the lining. The slag tapped from the cupola differs from a typical blast-furnace slag in that it contains anything from one to 25 per cent. of ferrous oxide. This ferrous oxide, which incidentally is a direct source of iron loss, is caused by oxidation of metal taking place in the melting zone, and the amount present in the slag must be largely determined by the oxidising or reducing nature of the atmosphere maintained inside this zone. It can be readily appreciated that the slags formed at different positions inside the cupola may bear little relation to the composition of the final slag. It is well known that slags rich in ferrous oxide are particularly corrosive to acid refractories. Again, in the side-blown converter the composition of the final slag may analyse between 5 and 25 per cent. of FeO, but it is highly probable that the slags formed at the early stages of the blow are much richer in ferrous oxide than this, and consequently considerable corrosion of the lining takes place. Slag attack in the ladle has been appreciably aggravated by the growing tendency to desulphurise the metal in the ladle. These soda slags appear to be particularly corrosive

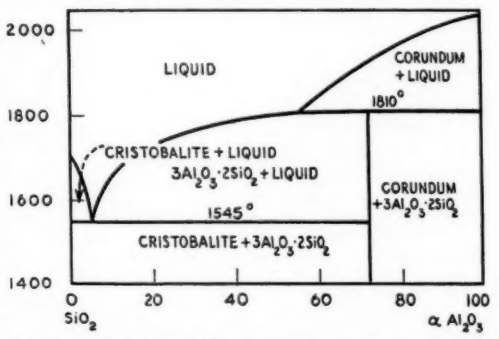

FIG. 1.—THE Al_2O_3-SiO_2 BINARY PHASE-RULE DIAGRAM AFTER N. L. BOWEN AND J. W. GRIEG.

*Presented at the London Conference of the Institute of British Foundrymen, June, 1948.

†The Authors are on the staff of the British Refractories Research Association.

Refractory Materials in the Foundry

in the case of brick ladles, the joints being rapidly worn back until the whole lining assumes a "cobble-stone" appearance. The weakness of the joints has proved a strong incentive to experiment with rammed linings, consisting either of the conventional ganister-clay mixtures or more recently of basic mixtures such as stabilised dolomite, magnesite-olivine and even magnesite itself.

The Choice of Refractory Materials

An appreciation of operating conditions often affords a valuable guide to the choice of refractory materials, and in the foundry, face temperatures over 1,700 deg. C., steep temperature gradients through the lining and the corrosive action of slags rich in ferrous oxide are three important factors to be taken into consideration. To-day, the converter is either lined with silica bricks or rammed, the ladle is lined with firebricks or rammed, while the cupola is usually lined with firebricks and then patched after each day's working. It is generally realised that all bricks should be laid with knife-edged joints since the joints are the weakest feature of a brick lining. The reversible expansions of the various modifications of silica are now generally understood, and it is appreciated that care is required during the initial heating of a newly-bricked silica brick converter lining until the temperatures corresponding to the inversion points of tridymite and cristobalite have been exceeded.

Data compiled by the Side-Blown Converter Sub-Committee have shown that there are wide divergencies in the properties of proprietary ramming and patching mixtures, and some thought can profitably be given to the constitution of these mixtures, which involves such factors as the percentage clay content and the grading of the aggregate. There are good reasons for asserting that the clay content should be a minimum consistent with the possession of the necessary workability for the ramming into a compact mass, or for adherence to the surface of the cupola lining after all slagged material has been removed from the old face. A low clay content makes for easier drying and for reduced drying and firing contractions, and therefore the prevention of surface cracks. Again, slag penetrates and reacts more quickly with a clay matrix than with the discrete grains of ganister or quartzite which form the aggregate. A more cogent reason, however, for maintaining the clay content at a minimum figure is revealed in the binary SiO_2-Al_2O_3 phase-rule diagram. The binary phase-rule diagram depicting the temperature of complete liquefaction of compositions of pure silica and pure alumina when equilibrium is maintained is given in Fig. 1.

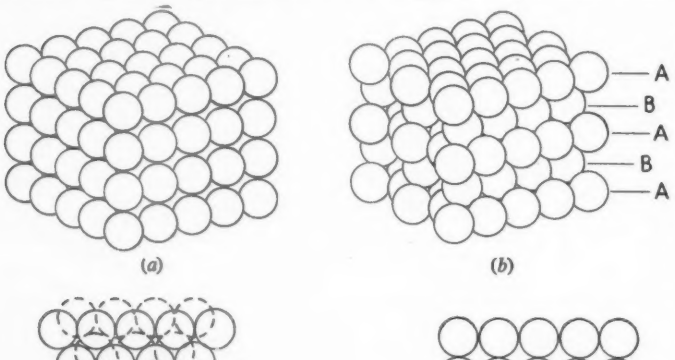

FIG. 2.—VARIOUS METHODS OF PACKING SPHERES OF EQUAL DIAMETER; IN (*a*) EACH SPHERE TOUCHES 6 OTHERS, AND THE PERCENTAGE OF VOIDS IS 47.64; IN (*b*) EACH SPHERE TOUCHES 12 OTHERS AND THE PERCENTAGE OF VOIDS IS 25.95.

Effect of Chemical Constitution

It will be observed that small additions of alumina quickly lower the temperature at which complete liquefaction of the mixture occurs, and whereas pure SiO_2 has a melting point of 1,720 deg. C., a mixture consisting of 5.5 per cent. Al_2O_3 and 94.5 per cent. silica, is completely molten at a temperature of only 1,545 deg. C. This diagram only applies if equilibrium be established. If the refractoriness values of silica bricks, siliceous bricks and firebricks be plotted against their alumina contents a similar type of curve is obtained, but the composition having minimum refractoriness now contains between 7 and 10 per cent. of alumina, and the softening value is about 1,520 deg. C. The discrepancy between the two graphs is due partly to the occurrence of other oxides in small amounts which are always present in refractory products, and also to the fact that equilibrium is not usually established during a refractory-test determination. Thus T. F. E. Rhead and F. E. Jefferson[3] showed that with siliceous materials, the refractoriness value is reduced if the material is finely ground, re-bonded into a cone and the test repeated.

The five monolithic ramming mixes cited in the First Report had Al_2O_3 contents of 6.0, 3.5, 6.3, 4.5 and 2.0 per cent. respectively. A. H. B. Cross[2] quotes 7.2 per cent. and W. J. Rees[4] 14.7 and 9.5 per cent. for the alumina contents of air-dried patching materials. Raw fireclays and ball clays usually contain between 30 and 35 per cent. of alumina, consequently to avoid this steep trough in the refractoriness curve, every effort should be made to limit the clay content of a ramming mixture to below 15 per cent. Since clay is used to confer workability and adequate green strength, it is most important that a clay which is naturally plastic should be chosen and further, that the plasticity be developed to the optimum extent by pulverising the clay as finely as possible before incorporating it in the ramming mixture. If the clay can be added in "slip" form so much the better.

Packing Density

The behaviour of the ramming or patching mixture is also influenced by the grading of the aggregate which is usually obtained by crushing a quartzite or ganister rock. The grading should be selected to give a high degree of packing, thus ensuring minimum porosity in the fired monolithic lining. The maximum size of the aggregate must obviously be related to the thickness of the lining and, in the majority of mixes, all material is crushed to pass a ¼-in. mesh. The type of grading required to give a maximum packing density can be deduced from purely theoretical considerations.

It can be shown that there are several ways in which spheres of one type can be packed into a cube. If each sphere be arranged, as in Fig. 2a, so that it touches six other spheres (four in the same plane and one each above and below) then the percentage volume occupied by voids is 47.64. The closest method of packing spheres of one diameter is shown in Fig. 2b, each sphere being in contact with twelve others. In this arrangement the percentage of voids is 25.95. However, spheres do not automatically arrange themselves into this close packed assemblage, if lead shot for example is poured into a vessel, the percentage of voids is about 44.

In order to decrease the volume of the voids below 25.95 per cent. it is necessary to allow the void spaces to be occupied by spheres of such size as to fit into the irregularly-shaped pockets. Further reductions in porosity can only be effected by using still smaller spheres which fit into the interstices between the primary and secondary spheres. Using six different sizes of spheres it is possible theoretically to reduce the total volume of voids to 3.9 per cent. The relative diameters of these six sizes are: r, 0.414r, 0.225r, 0.177r, 0.116r, together with very small spheres to act as filler material, while the corresponding percentage weights required are 77 08, 5.47, 1.75, 3.31, 0.97 and 11.42.[5]

It can be seen at once from these theoretical considerations that to obtain a close packing density, gap gradings are required consisting of a much larger proportion of the coarsest and finest grades than of the intermediate grades, and this has led in practice to gradings of the type; 45 per cent. coarse, 10 per cent. intermediates, and 45 per cent. fines. In making

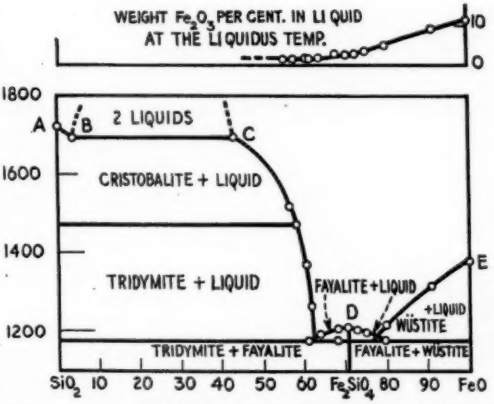

FIG. 3.—THE FeO-SiO_2 BINARY PHASE-RULE DIAGRAM AFTER N. L. BOWEN AND J. F. SCHAIRER.

ramming mixtures it is impracticable and wasteful to resort to screening with rejection of unsuitable grades, consequently the ganister should be crushed by such machinery as will automatically break the material down to a grading of the 45-10-45 type.

It has been found in practice that the solid-bottomed grinding pan is effective in crushing material to produce high bulk densities, but the optimum time of crushing on the pan must first be determined by taking samples at intervals and determining the bulk density by means of an A.F.A. rammer or other suitable means.[6] As the finely-divided clay must be included in the finest fraction this should be added to the pan at an early stage in the grinding. A high bulk density in the rammed lining, or what is equivalent, a low porosity, confers high mechanical strength both in the green and fired state, together with increased resistance to slag corrosion.

Precautions for Rammed Linings

During the installation of the rammed lining, great care must be taken to prevent laminations forming between successive layers as they are rammed. Careful attention must also be paid to the drying and preliminary firing. The clay minerals decompose at about 500 deg. C. with the elimination of water, consequently a monolithic lining is mechanically very weak above this temperature until the ceramic bond is developed at temperatures over 1,000 deg. C. At 575 deg. C. quartz undergoes inversion from the α to the β form with an increase in volume, and if the heating is too fast over this temperature range great damage might be caused to the lining and in extreme cases the whole lining might fall away, or patching material might drop off.

Careful control of the grading of the non-plastic portion of the mix will ensure a high mechanical strength in the fired state even though the clay addi-

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tion is maintained below 15 per cent. In Germany, firebricks are made from mixtures containing only 12 per cent. of clay, the grog being screened to give a high packing density. The clay is first made into a slip and then added to the grog, the bricks being tamped into moulds using an air hammer. After firing to 1,300 deg. C. these bricks have porosities between 12 and 16 per cent. and crushing strengths as high as 10 tons per sq. in.[7]

The Action of Ferrous Oxide Slags

In the brief survey given above, emphasis has been laid on the corrosive nature of the ferrous-oxide slags which attack the linings of the various foundry units. The rate of wearing back of the face is a complex phenomenon involving many factors, among which are: (1) the texture and mineralogical composition of the refractory; (2) the nature of the slag, its chemical composition, viscosity and interfacial tension at the refractory surface; (3) the nature of the reaction products formed between slag and refractory, their composition, amount and physical properties such as melting point, viscosity, etc; (4) the rate and mechanism by which those reaction products can be removed and replaced by fresh slag; (5) the temperature of the hot face and the temperature gradient through the refractory, and (6) the presence of cracks, laminations or joints into which slag can readily gain access.

The phase rule provides an important theoretical approach to the problem of slagging. The two most important diagrams which can be applied to acid refractories are the binary FeO-SiO_2 diagram (Fig. 3) and the ternary FeO-Al_2O_3-SiO_2 diagram (Fig. 4).

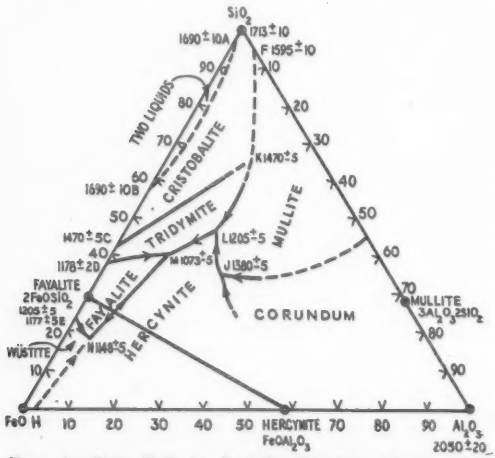

FIG. 4.—THE FeO-Al_2O_3-SiO_2 TERNARY PHASE-RULE DIAGRAM AFTER J. F. SCHAIRER.

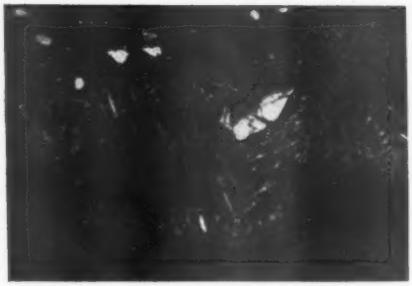

FIG. 5.—THIN SECTION OF THE SLAG-BRICK INTERFACE OF A RUNNER BRICK SHOWING QUARTZ GRAIN WHICH RESISTS SOLUTION.

In the case of the FeO-SiO_2 diagram the temperature at which complete liquefaction takes place is shown by the line ABCDE, which is known as the liquidus curve. It will be observed that small additions of FeO to SiO_2 lower the temperature of complete liquefaction, but continued additions have no further effect until a concentration of 42 per cent. of FeO is reached, after which the liquidus curve drops to a minimum at about 1,180 deg. C. This is quite different from the Al_2O_3-SiO_2 diagram discussed earlier, where additions of Al_2O_3 to silica continually reduce the temperature of complete liquefaction until a minimum value is obtained with 5.5 per cent. alumina. The horizontal portion in the liquidus curve occurs because the FeO and SiO_2 compositions at this temperature melt to form two immiscible liquids, the area of immiscibility being represented by the dotted curve.

This region of immiscibility causes the composition with the minimum melting point to be displaced appreciably to the FeO side of the diagram. This is of immense practical significance since it means that appreciable concentrations of FeO have to be attained at positions just behind the hot face of a silica brick converter lining before complete liquefaction occurs. The presence of alumina in quite small amounts destroys this liquid immiscibility, as can be seen from the FeO-$Al_2O_3SiO_2$ ternary diagram (Fig. 4), less than 3 per cent. of alumina being sufficient for this purpose. From such a diagram, when complete, much data can be directly inferred, such as the mineral first appearing when a melt of any given composition is cooled and the final composition of the mass when complete solidification has occurred. The temperature at which liquid first forms, the temperature of complete liquefaction, and the relative percentages of liquid and solid, together with their respective compositions between these temperatures, can all be ascertained. According to the FeO-Al_2O_3-SiO_2 diagram as determined by J. F. Schairer,[8] a composition corresponding to the point M, 40.3 per cent. SiO_2, 12.5 per cent. Al_2O_3 and 47.2 per cent. FeO is completely liquid at 1,073 deg. C.

However, when applying phase-rule data to interpret the behaviour of refractory materials, the limitations

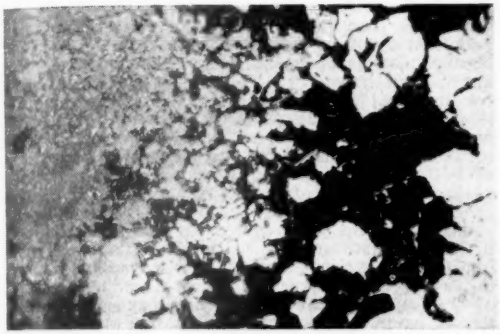

FIG. 6.—THIN SECTION OF THE WORKING FACE OF A SILICA BRICK FROM A SIDE-BLOWN CONVERTER LINING.

of these diagrams must always be borne in mind. Such diagrams only relate to pure oxide systems, whereas silica and firebricks contain small but significant percentages of several other oxides in addition to silica and alumina. From the ternary Al_2O_3-FeO-SiO_2 diagram it is at once obvious that the Al_2O_3 content of a silica brick is very critical, and small variations in this constituent may appreciably alter the resistance of silica bricks to ferrous oxide slags. Again, the phase-rule diagrams relate only to mixtures in equilibrium. With a heterogeneous material like a firebrick or monolithic lining, slags usually attack the matrix in preference to the grog or silica grains. Fig. 5 shows a thin section through the brick and slag interface of a fireclay runner brick where a crystal of quartz has resisted solution by the slag which has dissolved the matrix from all sides of the crystal and left it surrounded by slag. Microscopical examination of samples from either the working face of a silica brick or that of a rammed monolithic converter lining present similar features. At the surface, all quartz has been converted to cristobalite, but it is evident from Fig. 6 that the black slag has penetrated into the lining by way of the matrix and interstices between the larger grains since the grains themselves can resist solution much more effectively.

Methods of Testing

Many tests have been devised to simulate more closely the mechanism of slag attack as it occurs under industrial conditions. In one such test, a small cylinder of slag is placed on the horizontal brick surface and the assembly heated until the slag melts and penetrates the brick. After cooling, the diameter and depth of penetration of the slag are noted by cutting the brick vertically through the centre. It is obvious that erroneous deductions are likely to occur if the final slag from the cupola or side-blown converter be used in such a test instead of the initial slags which are much richer in ferrous oxide. A second method of studying slag corrosion consists of grinding the refractory material to a powder and mixing this with various proportions of powdered slag to give a series of compositions ranging from pure brick to pure slag. The mixtures are then pressed into cones and the refractoriness value of each composition is determined. Obviously such a test cannot take into account such important factors as the texture of the refractory material, the temperature gradient, or the mechanical action of the slag in abrading the working face. Nevertheless, important observations are often revealed by such an investigation, and the author has recently completed determinations on the refractoriness values of a wide selection of acid refractories with various percentages of pure FeO.[9] In carrying out these tests the refractoriness value has to be determined in a neutral atmosphere, and the cone must be surrounded by an iron ring, otherwise oxidation of the FeO will occur. The softening temperature of the cones for varying compositions of FeO refractory are given in Fig. 7 (*a*) and (*b*). It will be observed that with silica bricks (over 94 per cent. SiO_2) the softening temperature of the cone did not drop below 1,400 deg. C. until the concentration of FeO exceeded 40 per cent., an observation in line with the theoretical deductions made with the binary SiO_2-FeO phase-rule diagram. With a 70 per cent. alumina brick, the addition of 10 per cent. of FeO was sufficient to reduce the refractoriness value to 1,400 deg. C., and a firebrick containing 61 per cent. SiO_2 and 32 per cent. Al_2O_3 had its refractoriness value markedly reduced by the incorporation of 20 per cent. FeO, while with 40 per cent. FeO the refractoriness value was below 1,100 deg. C. The tests have also shown that siliceous bricks containing about 88 per cent. SiO_2, comparable in composition with monolithic ramming mixtures, are very similar to silica bricks in that the refractoriness value is not reduced below 1,400 deg. C. until the composition of the mixture contains 40 per cent. FeO. The refractoriness "squatting" test is valuable in giving an indication of the temperature at which an appreciable amount of liquid phase is formed, but it also gives some indication of the viscosity of the liquid. Visual observations showed that all cones made from

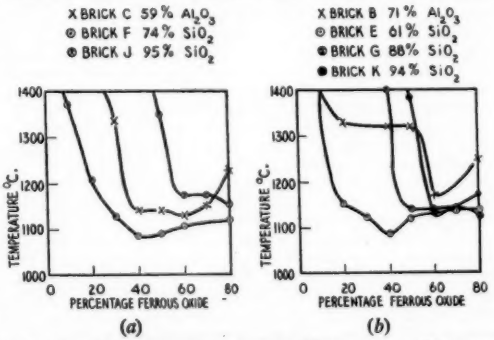

FIG. 7.—THE REFRACTORINESS VALUES OF VARIOUS FeO, WITH POWDERED REFRACTORY COMPOSITIONS USING SILICA BRICKS, FIREBRICKS AND ALUMINA REFRACTORIES

Refractory Materials in the Foundry

FeO-silica-brick compositions squatted suddenly, while the corresponding cones containing the siliceous brick squatted more gradually, suggesting that more viscous melts were obtained when FeO attacked siliceous products.

Petrological and X-ray examinations made on the fused cone mixtures indicated certain fundamental differences, since the reaction products formed between silica bricks and FeO were found to contain the orthosilicate mineral fayalite $2FeO.SiO_2$, whereas the reaction products formed between the siliceous brick and FeO contained meta-silicates approximating to $FeO.SiO_2$ in composition and belonging to a class of minerals known as the pyroxenes.

Relation between Viscosity and Atomic Structure

Viscosity is a complex phenomenon related to the atomic configuration of the liquid. The atomic structure of crystalline fayalite is built up of discrete SiO_4 groups in which the four oxygen atoms are arranged at the corners of a tetrahedron, the silicon atom being located in the pocket at the centre. The iron atoms are much smaller than these SiO_4 units and are arranged among them. The pyroxene minerals, on the other hand, crystallise in long laths and the silicon and oxygen atoms are arranged in endless chains which are continuous throughout the crystal. These chains are much larger units than the discrete SiO_4 groups found in fayalite. At the melting point the ordered arrangement of atoms in the crystal is largely destroyed, but even in the liquid state the atoms tend to group themselves into definite formations which resemble those found in the crystalline state, the chief difference being that in the liquid state such formations are continually breaking down and reforming.

These formations, in the case of melts which crystallise to form pyroxenes, are much larger than those in the corresponding melts which crystallise to give fayalite, and this explains why the reaction products formed from FeO and siliceous bricks are more viscous than those from FeO and silica bricks. J. White[10] has suggested that the more viscous nature of the slags formed at the surface of a monolithic converter lining affords an explanation why such linings are comparable with silica bricks in their resistance to slag attack although these latter possess a markedly superior refractoriness value.

However, it must be admitted that X-ray and petrological examinations of the slagged face of monolithic ramming mixtures and silica bricks do not invariably reveal the presence of pyroxenes in the one case and fayalite in the other. It is probable that, after the molten metal is poured from the converter, these minerals are rapidly oxidised to magnetite, ferric oxide and silica.

Value of Basic Refractories

It may be thought that silica and siliceous products could be replaced with advantage by other materials more resistant to ferrous-oxide slags. Basic linings have been tried both in the cupola and the ladle because they have the great advantage of assisting de-sulphurisation of the iron. Stabilised dolomite, the material most generally used, consists essentially of free magnesia in a groundmass composed of calcium silicates. When attacked by ferrous-oxide slags, the magnesia crystals absorb the ferrous oxide forming a solid solution. This is because the atomic structures of FeO and MgO are very similar, both consisting of a rigid framework of oxygen atoms in which each metal atom fits into the pocket formed by six oxygen atoms. Since the magnesium atom and iron atom in the ferrous state are not widely different in volume, iron atoms can progressively replace magnesium atoms in the oxygen framework forming a continuous series of solid solutions ranging from pure magnesia to pure ferrous oxide.

This property of solid solution formation imparts a characteristic form to the liquidus curve of the binary FeO-MgO diagram, which in consequence does not show any minimum value between the melting point of FeO (1,370 deg. C.) and that of MgO (2,800 deg. C.) (Fig. 8). The high melting point of magnesia, together with the absence of any minimum in the liquidus curve, means that magnesia can absorb twice its own weight of ferrous oxide before the temperature of complete liquefaction falls below 1,680 deg. C. Magnesia is thus the most resistant of all refractory materials towards ferrous oxide slags, and only its poor resistance to thermal shock prevents this material from being used more extensively.

Mechanism of Slag Attack

For slag attack to occur in a progressive manner, some mechanism must be present for continually removing the products of reaction, thus exposing fresh refractory to further attack. The mechanism is variable and sometimes complex. In a simple case

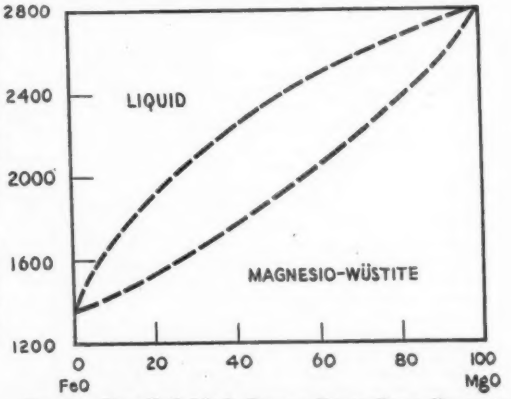

FIG. 8.—THE FeO-MgO BINARY PHASE-RULE DIAGRAM AFTER N. L. BOWEN AND J. F. SCHAIRER.

the products of reaction might be so fluid that they run down the surface of the working face until they come to a position of lower temperature where they freeze and collect as a solid mass. Again, the attacked surface may be continuously abraded away by the action of liquid metal or slag in a state of turbulence or by the abrading action of dust- or slag-laden gases. Liquid iron in motion has a marked scouring action, for example it has been found by A. E. Dodd[11] that the lining of a steel ladle wore back 4.1 in. at the position where the metal stream struck the wall as it fell from the launder, while other parts of the ladle only wore back 2.85 in. Again, during the teeming of 60 tons of molten steel, the diameter of the nozzle may increase by as much as 50 per cent. owing to the erosive action of the molten iron.

Dust-laden gases are markedly abrasive and channelling of the gas stream in the blast furnace can often be inferred from the presence of localised grooves in the lining which have been scoured out by the gas stream. As refractory linings are porous, the products of reaction may penetrate into the refractory, and freeze at some position a definite distance behind the hot face determined by the temperature gradient through the lining. In this way a zone of slag penetration may build up behind the hot face. Any temperature fluctuations may then result in the development of stresses which may cause the working face to flake off in layers. The conversion of the hot face of a silica brick to cristobalite, while the remainder of the brick consists in part of other modifications of silica, can produce a similar type of flaking. It is difficult in the laboratory to simulate many of these aspects of slag attack which occur under industrial conditions and, in particular, this continuation of chemical attack and mechanical abrasion which may take place either simultaneously or alternately.

Conclusions

The considerations of lining failures discussed above apply more particularly to the comparatively slow but continuous wearing back of the refractory which occurs during normal service. Opinion is often expressed that the life of a lining is almost entirely dependent on the operating conditions, while the quality of the refractories is only of minor significance. It is certainly true that more damage can be done to an installation during the few minutes in which operating conditions have got out of control, than occurs during months of normal working. If the quality of the refractories appears to exert little influence on the life of the lining it might be argued that there is a *prima facie* case for attempting to obtain closer control of the metallurgical operation. One has only to observe the great increase in instrumentation which is taking place in such important units as the blast furnace and open-hearth furnace to realise that this point is now being appreciated, and it is obvious that as the operating conditions are more rigidly controlled, so the quality of the refractories will play an ever increasing part in determining the working life of the unit.

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DISCUSSION

MR. H. G. HALL, commenting that the Authors had confined their remarks to cupolas, converters and ladles, drew attention to another important unit, *i.e.*, the rotary furnace. He asked whether the condition of the grog or aggregate affected the refractory values and the expansion characteristics of the lining as a whole. To clarify his meaning he asked, if a monolithic lining were made from, say, crushed pebble or if it were made from crushed silica brick, was there an advantage one way or the other? Was there a danger in maximum packing density from the point of view of expansion, and possibly rupture of the container.

With regard to the iron content of slag, he said he had made a brief survey of the slag produced by various manufacturers from their rotary furnaces, and had found that there was a variation of from 2 to 25 per cent. of iron oxide. From the Authors' remarks it was obvious that such variations would markedly influence the refractory life.

The point that reliance was largely placed on the temperature gradient between the hot face of the lining and the outer shell recalled to his mind a humiliating experience he had had some years ago. In his ignorance he had thought that he could improve the thermal efficiency of the furnace by putting an insulating layer between the refractory and the shell; but the refractory had collapsed very quickly.

Monolithic Linings

DR. RIGBY, replying to the question concerning the use of crushed pebble or silica bricks said the expansion properties of those two ramming mixtures would be very different. Crushed pebbles were essentially quartz, and quartz had a high coefficient of expansion over a very limited temperature range round about 575 deg. C. The result would be a danger point when the mix was first heated, and care should be taken, in raising the temperature of the ramming mix initially, to ensure that the temperature over that limited range at about 575 deg. C. was not increased too quickly. On the other hand, in silica bricks most of the quartz had been converted into cristobalite, which had a high coefficient of expansion round about 200 to 300 deg. C., so that there was a danger at that lower temperature when using silica brick. He was of opinion, on the whole, that in ramming mixtures, ganister, or even pebbles, were likely to give better service than crushed silica brick.

It was quite true that in most foundry units the ferrous oxide content of the slags varied very widely.

Refractory Materials—Discussion

On analysing the slag, even from a cupola, sometimes there was no ferrous oxide in it, whereas sometimes cupola slags had an appreciable ferrous oxide content. As Mr. Hall had rightly remarked, that would have a serious influence on the life that could be expected from a lining. Even so, Dr. Rigby suggested that the analysis of the final slags did not give a very clear picture of what was going on. Probably when the slag was initially formed it had a very much higher content of ferrous oxide than had the final slag because the final slag represented the initial slag, after it had attacked the refractory and the ferrous oxide had been diluted in consequence. The initial slags must be quite rich in ferrous oxide, and that applied to all the units—the converter, the cupola and, he was interested to hear, the rotary furnace also.

Danger of Over-insulation

It was not at all surprising that a layer of insulating material between the refractory and the shell had proved disastrous. The temperature gradients through the lining were very much flatter when insulating materials were used, and consequently, slags could penetrate more deeply into the lining before they froze. The case mentioned by Mr. Hall was by no means an isolated one; such disappointing results occurred in many units where insulation was applied. It was the steep temperature gradient which maintained the resistance of the refractory against slags; that was why, in many cases, water cooling was very much more helpful than insulation.

Influence of Iron Oxide on Acid Refractories

DR. R. V. RILEY, referring to Fig. 3 of the Paper, which was the binary FeO-SiO_2 phase-rule diagram, said he had understood from Dr. Rigby that an addition of iron oxide to the silica of up to 40 per cent. resulted in very little diminution in refractoriness. From the diagram, however, he had noted that in the range from, say, 1,450 deg. to the horizontal at 1,700 deg., there was a region of cristobalite plus liquid, and from just under 1,200 deg. up to 1,450 deg. there was a region of tridymite plus liquid. He would have suggested that in those regions the material would be somewhat pasty, that the brick would not be firm and solid, but would be in process of fusing down. He asked if that contention were correct.

DR. RIGBY agreed that Dr. Riley's deductions were correct, in that there was some liquid formed at a comparatively low temperature. The curve labelled A-B-C-D in Fig. 3 indicated where complete liquefaction occurred; there was no solid material present in the region above that curve. Below the curve there was a region of cristobalite and liquid and a region of tridymite and liquid, *i.e.*, in those regions there was both solid and liquid present; the straight line just below 1,200 deg. on the diagram indicated the point below which the material was quite solid, there being no liquid at all. The important point was, however, that the actual refractoriness value did correspond fairly closely with the curve A-B-C-D.

For example, some liquid is present in a firebrick at as low a temperature as 800 deg. C., and yet the refractoriness value might be nearer 1,700 deg. C.; the latter being the temperature at which sufficient liquid was formed to cause the material to slump under its own weight. So that although the temperature at which the first signs of the formation of liquid occurred was important, the temperature at which the whole became liquid was likely to be a surer guide.

Clay Content

MR. H. G. HALL said that in the Paper there was a tendency to emphasise that one should work towards the left-hand side of the diagram, but he felt it advisable to point out the danger in that; it was that, the higher one went towards the silica end with a monolithic lining the more sensitive was that lining to thermal shock in service, to the week-end shut-down, or even the night shut-down. Therefore, if such compositions were used, as indeed thy must be, for high temperature melting, then the hot face must never be allowed to drop below 300 deg. C.

DR. RIGBY, whilst agreeing with Mr. Hall, said he would not have thought that it was so terribly important, because he was pleading for a reduction of clay content from 20 per cent. to 15 or 12 per cent. That meant an increase in aggregate content, pure silica more or less, of less than 10 per cent., from 80 per cent. to something like 86 or 87 per cent., and he did not think that that would greatly increase the sensitivity of the mix towards spalling. Anyway, any increase of sensitivity would be more than compensated for by the increased resistance to slag attack which the mix would possess.

Carbon as a Refractory

THE CHAIRMAN (Mr. John Sheehan, Junior Vice-President) said that Mr. Talf, of the Idoson Motor Company, Birmingham, had been successful with the addition of coke granules to the ground refractory mix, using a high quality metallurgical coke and was very confident of its value. Mr. Sheehan himself had tried it, but with limited success. He asked Dr. Rigby whether the matter had any association with the plasticity, which was shown on the curve in Fig. 3, and to which Mr. Riley had referred. Certainly the coke addition would minimise the plastic effect that was obtained in a mixture of solid and liquid.

Another matter about which he had been concerned in the past—and Dr. Rigby had dealt with it in reply to Mr. Hall—was that of the ramming densities, which had arisen in connection with scabbing in hard rammed sand moulds in the foundry. He recalled his efforts* to prove the number of voids there were between particles, which efforts had involved a lot of sweat and mathematics. Dr. Rigby, however, had been able to deal with the matter in a paragraph or two, and his figures corresponded with those which, in Mr.

* Core Shop Control, by J. J. Sheehan. Proc. Inst. of Brit. F., 1939-1940.

Sheehan's recollection, he himself had worked so hard to obtain.

Carbon in Blast Furnace Practice

DR. RIGBY was very interested in Mr. Sheehan's remarks concerning the use of coke in a refractory mix, because carbon—and that was coke, for all practical purposes—was coming very much to the forefront as a refractory material, particularly in the blast furnace. Great trouble had always been experienced in the well of the blast furnace, where the metal collected, because under the conditions prevailing there, firebricks tended to shrink and to slag, whereas carbon did not shrink and did not slag with ferrous oxide. Consequently carbon was likely to be a very important and useful refractory for the blast furnace. In the blast furnace the atmosphere was reducing, and that was why one could be successful with the use of coke. Unfortunately, carbon oxidised; so that, where there were oxidising conditions, the coke would burn away, and the last stage would be considerably worse than the first. If coke were added to a ramming mixture and the conditions of the use of that mixture were such that the coke would burn out, then obviously the mixture would become very much less resistant to slag attack, because there were huge voids to which the slag could obtain easy access. On the other hand, the coke would increase considerably the resistance to slag, because it did not react with iron oxide and, as the Chairman had pointed out, it was a highly refractory material and it was likely to maintain the refractoriness value. So that he felt that the success or otherwise of coke additions depended entirely on whether or not the coke could be kept in the lining and would not burn out; if it could be depended upon to remain in the lining it was likely to prove beneficial.

With regard to the Chairman's kind remarks concerning what were considered to be the Author's calculations for maximum packing density, Dr. Rigby said they were indebted for these figures to a Paper by A. E. R. Westman, and reference is made to this Paper in the text. Credit for them could not be given to Mr. Green and himself.

MR. J. H. COOPER said he believed the original use of coke in refractories extended back about 100 years; it was added to linings to allow for the expansion of the clays on burning. A typical mixture of a crucible lining used to be 3 qtrs. and 14 lbs. of Segger clay, 3 qtrs. and 14 lbs. of China clay, and about 14 lbs. of coke. Coke was added to rotary furnace mixtures, not so much for its refractoriness, but to allow for the expansion which occurred during heating.

Recalling the Author's reference to the 88 per cent. silica material, he said Dr. Rees had once commented that he could not understand why that material should stand up at all because, according to the eutectic, and so on, it was useless. It had 88 per cent. silica and about 6.5 per cent. alumina. Some of the ramming materials contained about 92-93 per cent. silica.

Finally, he asked to what Dr. Rigby would attribute the great divergence which could occur in the silica-alumina combinations. Was it the physical condition of the alumina or was it a chemical change which caused the trouble?

DR. RIGBY replied that it was quite true that the refractoriness value was dependent on how the alumina was present in a ramming mixture as well as on its content. If there were two ramming mixtures of similar alumina content, but in one case the alumina was all concentrated in the clay matrix, whereas in the other case an inferior ganister was used which itself contained alumina, he suggested that the mixture containing the inferior ganister was likely to give poorer results, because the alumina was much more evenly distributed throughout the mixture and it would be more detrimental in that state. Such things were very difficult to account for by figures on paper, but in practice they had an enormous bearing on the service obtained from the lining.

Publication Received

Slinger's Handbook. A small paper backed booklet, containing hints and useful tables for slinger's employed in iron and steel works, has been made available by the Sheffield Group of the Royal Society for the Prevention of Accidents. It lists sizes of chain and ropes for various slinging methods against maximum loads to be lifted. Also set out are standardised manual signals for giving directions to crane-drivers. This is the sort of information which managements, in the interests of safety, should provide for all men using lifting tackle. The handbook may be obtained from J. Atherton, Thos. Firth & John Brown, Limited, Atlas Works, Sheffield 1, price 7s. 6d. for 25 copies.

Notes from the Branches

South Africa. The annual general meeting of this branch of the Institute of British Foundrymen was held at the Hotel Victoria, Johannesburg, on June 25. Mr. H. Teubes was elected president and Mr. W. C. Simpson vice-president for the forthcoming session. Mr. K. L. Futter, Mr. C. Batchelor and Mr. F. J. Bullock were elected members of the Council.

A LECTURE on "Foundry Practice," illustrated by slides, will be given by E. L. Graham to the Wolverhampton Graduate Section of the Institution of Production Engineers, at the County Technical College, Wednesbury, at 7.15 p.m. on September 9.

A PARTY OF MEMBERS of the Technically Controlled Castings Group and their friends are leaving London on Saturday for a ten-day visit to Sweden, where they will study conditions and processes in many of the leading foundries, including A.B. Gottaverken, Gothenburg, S.K.F., Gothenburg and Katrineholm, the Norrahammar-Husqvarna works at Jonkoping and A.B. Svenska Elektriska Allmanna, Vasteras. The visit has been arranged by John Gardom and Company, Ripley, Derby, the consultants and secretaries to the Group.

London Conference Discussion

Nodular Cast Irons, Their Production and Properties*

(*Continued from page* 200.)

Double Heat-treatment Technique

MR. MORROGH said he wished to correct one point referring to a previous reply he had made. He did not say that these materials had necessarily a higher shrinkage—he pointed out that the tendency to external sinking was greater. Nodular irons would be expected to possess different shrinkage and sinking characteristics from those of grey cast iron; they solidified as white irons and most of their graphitic carbon formed after solidification. This form of solidification resulted in unique shrinkage, sinking and porosity characteristics which would have to be dealt with on the basis of gradually accumulated experience.

With regard to varying sections, they had made many castings of widely varying sections, actually covering wider limits than those mentioned by Mr. Hunter, without encountering any particular difficulty due to the section size.

Mr. Hunter had asked about the inoculation technique to eliminate the tendency for white iron formation. Actually the double treatment technique did reduce the chilling characteristics of the material considerably. In a Paper given the previous month and published in the "American Foundryman," some examples were given to illustrate that point. With regard to heat-treatment of the material, in all cases when they had either quenched or, rather, rapidly cooled to obtain fine pearlitic structures, they had not obtained any ferrite, so the question raised by Mr. Hunter had not entered into their considerations of the resultant mechanical properties.

Retention of Essential Properties

DR. A. B. EVEREST said that, like some of the last speakers, several of the points he had in mind had already been answered. He would like to compliment the Authors on an excellent piece of research work. The idea of a nodular graphite structure had been in the minds of research workers and foundrymen for many years past, and there were references in the literature stressing that such structures would provide castings with extremely good mechanical properties.

He would like to comment on the special mechanical properties disclosed in the Paper, since he was on the B.C.I.R.A. Committee concerned with those properties. The results showed that on the whole the nodular graphite cast irons had the sort of properties which one would expect. They were more than mid-way between the properties of ordinary cast iron and steel. This led him to issue a word of warning lest the development of these new cast irons went too far and lost the valuable properties of the ordinary metal. It was wise to bear in mind, for example, the desirable properties of cast iron in crankshafts. If the damping properties of cast iron were lost, they might be getting away from the desired quality of material which would give the best service in such shafts. Again, in the microstructures shown, it was evident that in almost every case each nodule of graphite was surrounded with an envelope of ferrite. He had a suspicion that that envelope of ferrite might have a very important bearing on the wear-resistant properties of the iron under review.

The question had already been raised that the new iron might not be good for parts subject to wear, such as cylinder liners, because the ferrite content spoilt the wear resistance. Undoubtedly this difficulty would be overcome as research progressed, and it had already been shown that a nodular graphite iron with a completely pearlitic matrix could be made. That brought him to the last point. In his introduction Mr. Morrogh referred to future developments, and there had been references to at least one other process. It was too early yet to give any details about these other processes, but such further researches indicated that, while the B.C.I.R.A. had started their work on cerium, it was possible that future work might ultimately depend on alternative additions, or on some combination of additions which would overcome some of the deficiencies seen in nodular cast iron to-day.

Wear Resistance

MR. MORROGH thanked Dr. Everest for his complimentary remarks, and said he quite agreed that many cast irons in many applications might well be better having flake graphite structures rather than nodular. It was possible that the rather inferior damping properties of nodular cast irons might limit their application in certain directions. But in connection with damping capacity, he did feel that in some cases the importance of this property was somewhat exaggerated. On studying the development of the cast-iron crankshaft, he believed it was found to be cheaper and more practical, and damping capacity was thought of afterwards.

With regard to the envelope of ferrite around the nodules, of course, that did influence the mechanical properties. It was possible that considerations of wear resistance would be of paramount importance in that context. He endorsed the remarks which Dr. Everest had made. They knew the cerium process was just one of many possible processes, and they had to bear in mind the possibility that the future would see the introduction of new methods for the production of nodular irons.

MR. HALL asked if the general assumption in the Paper was that the material had to be grey as cast. Wasn't it true that, if they obtained a white or semi-white casting, that that casting could be reclaimed by heat-treatment?

MR. MORROGH agreed. When, for instance, the section size was too small for a given composition, or if too much cerium had been added, the tendency was to obtain a white cast iron with a hypereutectic graphite distributed through it, and that material, it had been found, would anneal fairly readily to give a ductile nodular iron.

*Paper presented to the London Conference of the Institute of British Foundrymen, June, 1948, and published in the JOURNAL, July 8, 15, 22 and 29.

Exchange Paper from the "Association Technique de Fonderie"

The Maurer Diagram and its Evolution and A New Structural Diagram for Cast Iron*

A Review of Constitutional Diagrams for Cast Iron

By H. Laplanche, Docteur ès Sciences, Ingénieur-Métallurgiste

(*Continued from page* 203.)

Modifications of the Maurer Diagram

In 1927, Maurer published, in collaboration with Holtzhausen, a second memoire, in which he studies, this time, what becomes of his diagram when the speed of cooling of the metal is changed. In this study, systematic tests are at last brought into play. The test-pieces used are all cylindrical test-bars of 30 mm. dia., obtained from cast iron melted in a crucible furnace, and to obtain varying speeds of cooling, the Authors used moulds at from 450 deg. C. to 250 deg. C., moulds at shop temperature and cast-iron chills. This diagram is reproduced in Fig. 13.[18] It has the same general appearance as the first one, but it does differ in two essential points:—

(1) The mistake in the first conception has been discovered and the diagram only refers to a fixed and constant speed of cooling. The Authors add that, according to their results, a cylindrical test-piece 30 mm. dia., cast in a baked mould, heated to 450 deg. C., gives the same structure, other things being equal, of course, as a test-bar 90 mm. dia. cast in green sand.

(2) There appears for the first time a very important modification of the original diagram. Two lines on the diagram, situated within zone II (cast irons with wholly pearlitic matrix), curve towards the top and the Authors indicate that the hatched area between these two curves, added to the original diagram, correspond to the region where cast irons are always pearlitic, even in the case of test-bars of extreme sizes of 10 and 90 mm. dia. (¼ in. to 3½ in.).

This alteration from the original aspect, and this bending of certain lines, bring to light the second error in Maurer's diagram, which was a mistake in plotting. In any case, it is clear, *a priori*, that, if the group of converging straight lines in Fig. 11 corresponded to reality, the structure of an iron with a very low silicon content (say 0.50 per cent., for example) and the T.C content of which was progressively increased from 3.50 to 4 per cent., it would pass successively through all the structural aspects. In particular, this alloy would have an entirely pearlitic matrix with 4 per cent. T.C and an entirely ferritic matrix, with 4.5 per cent. T.C. Now these results are definitely disproved by the facts. With test-bars 30 mm. dia. cast in green sand, it could even be said that, with 5 per cent. T.C, such an alloy with 0.50 per cent. silicon, cooled under these conditions, has a white or mottled structure.

Following on the same idea, an iron-carbon alloy, without Si, which can easily be made in the laboratory, and cooled under the same conditions, should have an entirely ferritic matrix, with a T.C content greater than 4.30 per cent. This result is likewise definitely disproved by actual experiment. It can be stated that a pure iron-carbon alloy, even when cooled very slowly and even with a high carbon content, solidifies in the metastable system. It should therefore be found in zone I and not in zone III of the diagram.

Finally, according to the diagram shown in Fig. 11, the structure of the pure iron-carbon eutectic would be indeterminate, since it is to be found at the intersection of all the structural zones, whatever may be the speed of cooling. Maurer, probably foreseeing this criticism, had, however, placed around this point a ring delimiting a kind of reserved zone, that of "mixed cast irons" (*meliertes gusseisen*).

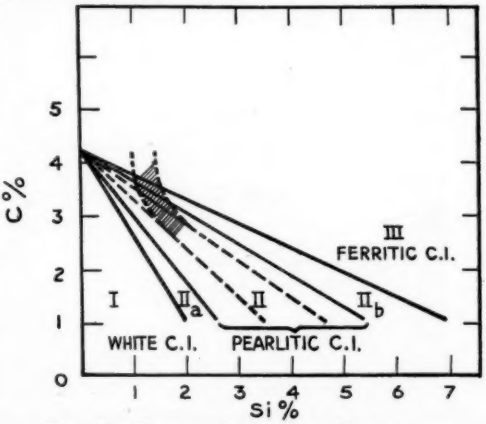

FIG. 13.—SECOND DIAGRAM OF MAURER AND HOLTZHAUSEN (1927).

*Presented to the London Conference of the Institute of British Foundrymen, June, 1948. Paper translated by R. W. Allott, M.A.

Structural Diagrams for Cast Iron

Portevin[14] writes on the subject of this error in the diagram:—"It is possible, certainly, with the view to simplifying the matter, to replace over not too long an interval function of its curvature, a curve by its chord, but it would obviously be a profound and inadmissible error then to extrapolate this straight line by prolonging it beyond the limits which have been adopted.

"Even if a curve, determined by experimental means, seems to be a straight line, one must be very careful in this extrapolation, which is, indeed, an indirect means of proving the inexactitude of the linear law, even though this seems, at first sight, to be representative of the phenomenon. Examples of this can be found in the representation of certain phenomena, in which speed decreases with time, such as phenomena of reactivity, relaxation, and contraction of quenched alloys. Experimental results appear, indeed, to be falling on a straight line as a function of the logarithm of the time. Extrapolation would lead to the conclusion that the lengths of the test-pieces will become nil for periods of time sufficiently long, which is inadmissible and proves the inexactitude of the linear law (Chevenard)."

As regards the Maurer diagram, the originator could have adopted, as a first hypothesis, and as the limits of the various structural zones, curves analagous to the "characteristic quenching curves" of steels[23] representing the various conditions of the steel after cooling as a function of the temperature, θc, of heating and the mean speed V of cooling. The extrapolation of the straight lines to the axis of carbon contents is inadmissible for the reasons pointed out above.

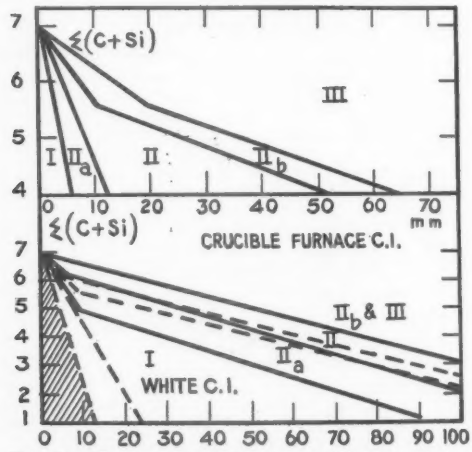

FIG. 14.—DIAGRAMS OF GREINER AND KLINGENSTEIN. (*a*) FOR CUPOLA RE-MELTED; (*b*) FOR CRUCIBLE RE-MELTED.

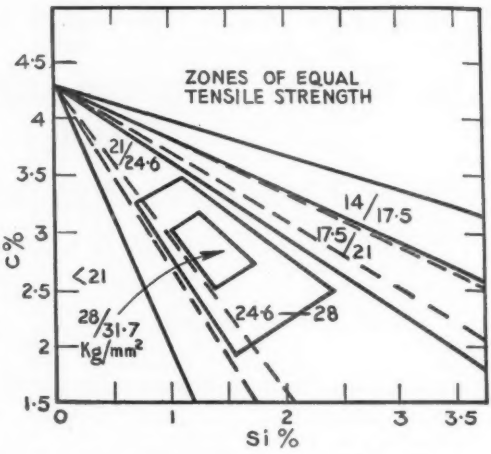

FIG. 15.—DIAGRAM OF COYLE, SHOWING ZONES OF EQUAL TENSILE STRENGTH.

The argument adduced by Maurer in his first memoire, namely, the search for an analogy with Guillet's diagrams, has no value, because the diagrams on alloy steels call for the same remarks. The content of 1.65 per cent. carbon, which is the meeting point of the straight lines in these latter diagrams, has no more significance, as regards the appearance of austenite in annealed alloy steels, than has the content of 4.30 per cent. carbon in Maurer's diagram in the appearance of graphite in cast irons.

These diagrams derive from the preceding ones. They show the structure of cast iron as a function of the sum of C plus Si as ordinates and of the size of the section of the test-piece as abscissæ ([19, 20]). The first diagram, Fig. 14 (*a*), relates, according to the authors, to cast iron remelted in the cupola, and the second (*b*) to cast iron remelted in the crucible. These diagrams were claimed to show the following points:—

(*a*) For the same value of the addition C plus Si, cast iron from the cupola would be "milder" than that from the crucible. The limits of the structural zones on the diagram, in the case of the crucible cast iron, Fig. 14 (*b*), are therefore displaced towards the right by reference to those on the diagram for cupola cast iron.

(*b*) In the case of cupola cast iron, it would be advisable to keep the total of C plus Si below 5.50 per cent., for the limit between zones II and II*b* would tend to deviate from this value, Fig. 14 (*a*), and the zone of pearlitic cast irons would become so much wider, and consequently so much less linked with the sectional area, as the total of C plus Si became lower.

Two errors can be found in these diagrams:—

(1) An error in drawing already pointed out, which consists of the fact that the limits of the zones are converging lines on a point situate on the axis of the

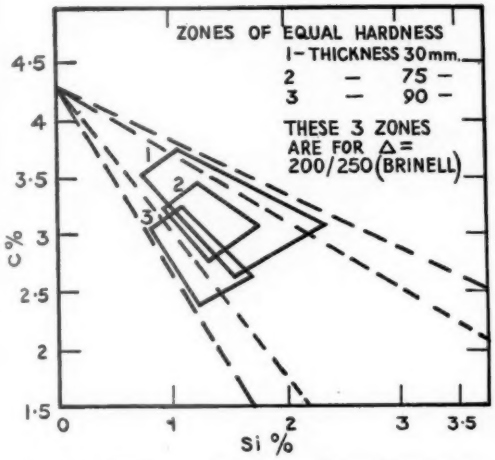

FIG. 16.—DIAGRAM FOR ZONES OF EQUAL HARDNESS.

ordinates C plus Si, and, (2) an error of conception, different from that of Maurer, which is that of assuming to reduce the chemical composition to only one independent variable, the sum of C and Si. Such an operation might indeed have been legitimate but it would have been indispensable to establish by experiment that each 1 per cent. of silicon behaved, as far as structure is concerned, in the same way as 1 per cent. of carbon, for a given speed of cooling. Now this hypothesis in no way conforms with actual fact; it is precisely its falsity which has been proved experimentally. It follows that the fact of representing the analysis by the sum of C and Si is a mistake similar to that which would be made by calculating an energy by adding together directly joules and calories without taking into account the coefficients of equivalence.

Coyle's Diagram

Other workers have sought to complete Maurer's diagram, but they have not reconsidered the problem from its beginning. In particular they have assumed his diagram to be valid and they have interited the errors which it contains. Thus, Coyle[22,23] has given us a diagram showing the zones of equal tensile strength, Fig. 15.

It will be noticed that the zone showing cast irons of maximum tensile only occupies the central portion of the field of pearlitic irons. This fact is plausible, since strength is linked, amongst other factors, to the fineness of the pearlite, measured by Belaieff coefficient Δ_0 and this coefficient varies within the pearlitic zone for a constant speed of cooling.

It will be noticed, however, that the lines of equal tensile are straight lines which come within the converging group of Maurer's rectilinear lines, without disturbing anything in the original drawing. This is, therefore, once again an extrapolation which is unjustified and erroneous.

The same remarks apply to the diagram giving the lines of equal hardness (Fig. 16) as well as to those which show, according to Frankenberg and Ludwigsdorf[24] the displacement of the zone of maximum strength as a function of superheating before casting (Fig. 17).

Norbury's Diagrams

Norbury was one of the first to publish simple experimental diagrams, in which he distinguished only three essential zones: (1) That of white or mottled cast irons; (2) that of cast irons with pearlitic matrix; and (3) that of cast irons with matrix partly or wholly ferritic.

He thus ignored the limits of the transitional zones.[25] Fig. 18 gives, for test-bars 30.5 mm., individually cast in green sand, the limits of these three zones, according to whether the graphite is punctiform or laminated (Fig. 2).

Fig. 19 shows, also, according to the form of the graphite, the displacement of the limits of the zones of white irons or mottled irons and of grey pearlitic irons. when the diameters of the test bars, under the same

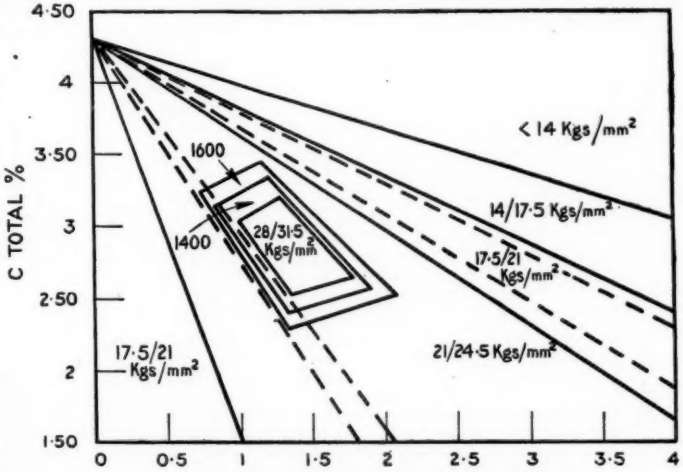

FIG. 17.—INFLUENCE OF SUPERHEATING ON THE POSITION OF THE ZONE OF MAXIMUM STRENGTH (TEST-BARS 40 MM. DIA.).

Structural Diagrams

experimental conditions as above, are decreased from 30.5 down to 10.16 mm.

It can be seen that the error of conception, contained in the initial diagram of Maurer, is not found here. This author gives two limits for the zones, one curved and one straight, but a given curve, as for example the limit between the white or mottled irons and the pearlitic cast irons, moves to the right when the average speed of cooling increases.

On the other hand, the curve in Fig. 18 is not exempt from all criticism, because a point of intersection of the limits of the zones is difficult to admit. Moreover, the line of eutectic compositions is shown here as a curve, whereas, as will be shown later on, it is, indeed, a straight line.

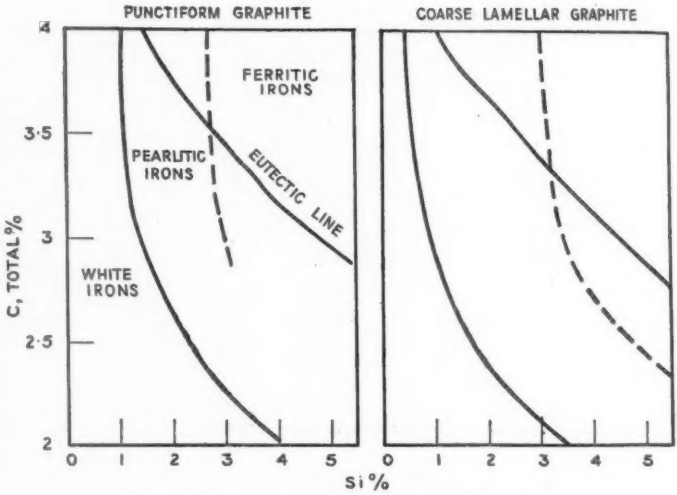

FIG. 18.—NORBURY'S DIAGRAMS FOR CAST IRONS CONTAINING MN 1.0, P 0.03, AND S 0.03 PER CENT. TEST-BARS CAST SINGLY IN SAND, DIA. 30.5 MM.

Diagrams of H. Uhlitzsch and W. Weichelt

In 1933 these two authors again took up the study of the structural diagram of cast irons as a function of three independent variables: T.C content, silicon content, and diameter of cylindrical test pieces, cast individually in green sand.[26]

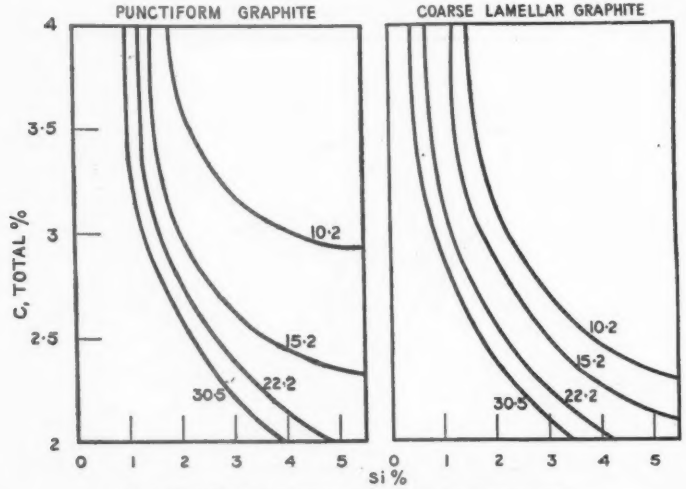

FIG. 19.—DISPLACEMENT OF THE ZONE LIMITS FOR WHITE, MOTTLED, AND PEARLITIC CAST IRON AS A FUNCTION OF THE DIAMETER OF SEPARATE SAND-CAST TEST-BARS.

Working for a Doctor's thesis at the School of Mines, Freiberg, they determined experimentally the limits of the various structural zones, on test pieces with diameters ranging from 3 to 30 mm. Fig. 20 shows the four diagrams obtained respectively for unit test bars of 30, 20, 10 and 6 mm. diameter.

These diagrams call for the following remarks:—

(1) The lines separating the different zones are curves, which, in a general way, are convergent towards the increasing silicon contents and divergent towards the increasing total carbon contents. Their concavity is turned upwards, as in the diagrams of Norbury.

(2) There is thus complete opposition between Maurer's diagram and the diagrams of Fig. 20, since Maurer's straight lines were convergent for increasing carbon contents and divergent for increasing silicon contents.

(3) The whole of the curves move towards the right as the speed of cooling increases, which is, in fact, normal, since the zone of the white irons should increase

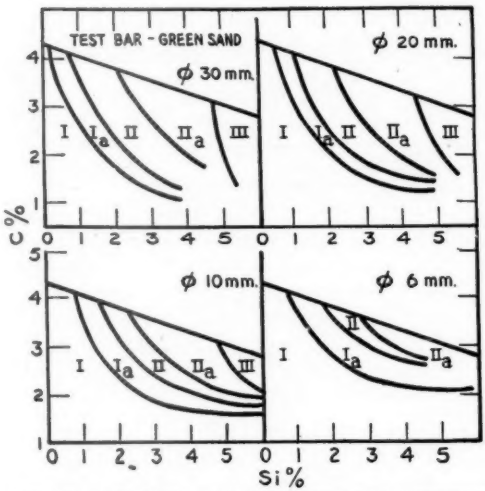

FIG. 20.—DIAGRAMS OF H. UHLITZSCH AND WEICHELT.

at the same time as the average speed of cooling increases.

(4) The oblique line limiting the upper part of the diagram corresponds to cast irons of eutectic composition, as will be later demonstrated.

These same authors have sought to de-limit the zone of cast irons with an entirely pearlitic matrix, as a function of the diameter of the test-piece. Fig. 21 shows the zones obtained for test-bars of 6, 10, 20, 30, 60, and 90 mm. diameter. In the upper part of the diagram they have confined their researches to hypo-eutectic cast irons. In the lower part, they have confined the zones to a horizontal around 2.50 per cent. T.C, which is arbitrary and is not confirmed by experiment.

It is to be noted that the more the section ot the test-pieces increases, the more does the influence of mass overcome that of external surface, so far as concerns the structure for a given analysis, with the result that, for a test-bar 90 mm. diameter, for instance, castings in green sand or in stove dried sand give practically the same interior structure, all other things being equal.

Diagram of Schwarz and Vath

In 1933 these authors first established experimentally that a cylindrical test-piece should have a diameter represented by $r \times 2$ mm. to give equivalent structure and the same characteristics as a cast plate having a thickness of r mm., the chemical analysis being the same in both cases. In these conditions, indeed, the same value is obtained for the specific surface of cooling, that is for the ratio between cooling surface and volume.

They have then shown that, in the case of complicated castings, such as cylinder blocks, where internal cores may become greatly heated during the casting operation and during cooling of the casting, the ratio between diameter of test-piece and thickness of corresponding casting must be adjusted. The relation between the thickness of a casting of rectangular section and the diameter of the corresponding test-piece then becomes

$$d = (2r + c) \text{ mm.}$$

In this equation c is a coefficient or factor of practical correction, which is a function of the type of casting in question. These results confirm the previous statements of Swift.[18]

Finally, Schwarz and Vath have tried to correct Maurer's diagram, and they have obtained experimentally the curves of Fig. 22, which give:—(1) On the one hand, the displacement of the axis of the pearlite zone when the diameter of the test pieces falls from 90 to 5 mm., and (2) on the other hand, the movement of this same axis for phosphoric cast irons with a P content between 1.10 and 1.40 per cent. when the diameter of the test pieces falls from 30 to 5 mm.

It can here be seen that phosphoric irons still give a pearlitic structure for thicknesses of the order of 5 mm., with a composition of 3.50 per cent. T.C and 2.30 per cent. Si, for example; whereas a hematite iron, for the same thickness and the same T.C would need from 2.7 to 2.8 per cent. Si. In a general way, for constant compositions of T.C and Si, phosphoric irons will maintain their pearlitic structure in sections which would already be giving a mottled or a white structure with hematite irons. Phosphorus acts therefore, in this respect, in the same direction as silicon.

Additions of Nickel and of Nickel-Chrome

Uhlitzsch and Coyle determined what became of the pearlitic zone when nickel, or nickel and chrome, were

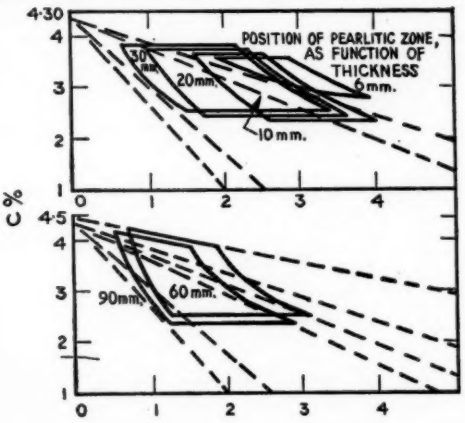

FIG. 21.—POSITION OF THE PEARLITIC ZONE AS A FUNCTION OF THE DIAMETER OF THE TEST-PIECE.

added to the cast iron.[29] Fig. 23 shows, comparatively:—(*a*) The pearlite field, according to Uhlitzsch (shown within curved lines on the diagram), and (*b*) the field of cast irons with maximum strength, for unit bars, 20 mm. diameter and for cast irons with the following compositions:—(1) Ordinary cast iron; (2) cast iron with addition of 2 per cent. nickel, and (3) cast iron with simultaneous additions of 0.50 to 1.25 per cent. nickel and 0.25 to 0.70 per cent. chrome.

Equations of the Curves of the Diagram

The structural diagram of iron-carbon-silicon alloys is composed, for a mean speed, V, of cooling, of a group of curves such that all cast irons corresponding to the same curve show an equal aptitude towards graphitisation. In fact, silicon acts first, during solidification, to tend to produce the deposition of free graphite. For each carbon content there is a silicon content above which no cementite still remains free after solidification. Yet silicon continues to act after solidification, and it plays as big a part during the transformations in the solid state as it does during solidification. It is, indeed, the silicon content which, for each value of carbon per cent. and for V, determines the proportion of pearlite remaining after complete cooling (or, what comes to the same thing, the proportion of free ferrite in the matrix.)

It is this point which has escaped certain foundrymen.[15] It is precisely the structural diagram which gives, for all the compositions Fe-C-Si, with a given average speed of cooling V, the resultant of all the changes from the liquid state down to shop temperature.

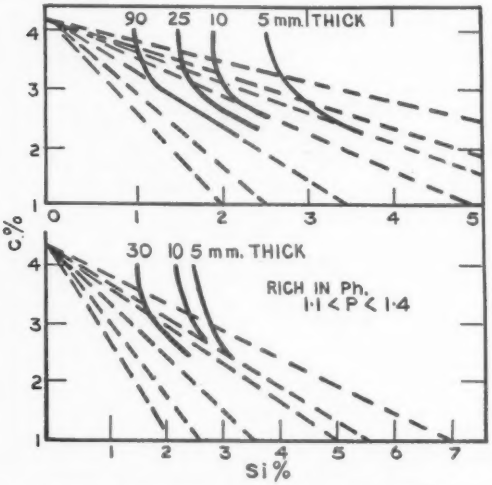

FIG. 22.—CORRECTIONS APPLIED TO MAURER'S DIAGRAM BY SCHWARZ AND VATH.

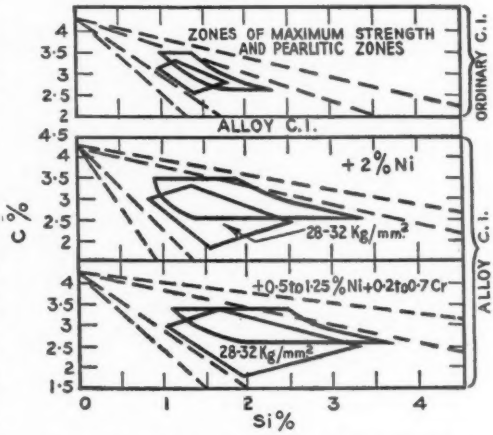

FIG. 23.—EFFECT OF ALLOYS ON THE ZONES OF MAXIMUM STRENGTH AND PEARLITIC ZONES.

The curves, which delimit the various structural zones, thus appear as particular curves in a network where each curve shows the contents of T.C and Si which must be brought together to obtain the same value for the ratio of the masses of graphitic carbon to total carbon at room temperature.

Obviously, each line of this family of curves is only valid for a given value of the mean speed of cooling V, namely, the one which has been adopted during the series of tests. Each curve on such a diagram is, in a way, an iso-graphitisation curve. In the zone of white irons, each curve is characteristic of an equal stability of the cementite.

(*To be continued.*)

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Core-Moulds for Stainless Steel Castings

Book-moulding applied to specialised Steelfounding

By R. S. Turner

The making of stainless steel castings presents many difficulties, and the method described here has been developed for making small items that were required in fairly large numbers at a reasonable cost. These castings are usually polished all over, therefore must be free from surface defects, and great care is necessary in all stages of manufacture.

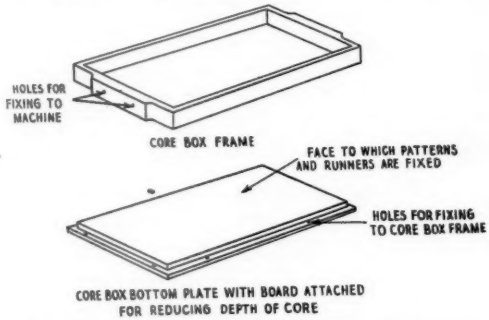

HOLES FOR FIXING TO MACHINE
CORE BOX FRAME
FACE TO WHICH PATTERNS AND RUNNERS ARE FIXED
HOLES FOR FIXING TO CORE BOX FRAME
CORE BOX BOTTOM PLATE WITH BOARD ATTACHED FOR REDUCING DEPTH OF CORE

FIG. 1.—CORE-BOX FRAME AND BUILT-UP BOTTOM PLATE.

Manufacturing Difficulties

Some of the difficulties are:—(1) Scabbing and sand erosion, especially with green-sand moulds, usually occurring in the runners, and the dislodged sand is then carried into the casting. (2) Stainless steel has a high liquid to solid contraction, and to reduce the risk of shrinkage defects it is necessary to cast as cool as possible. (3) On the other hand this material has a definite tendency to form cold-laps when cast at a low temperature, so that very careful control of casting temperature is necessary to maintain a balance between these two factors, and (4) Slag inclusions, particularly with materials containing Titanium.

It has been found that even with these small castings, dry-sand moulds are necessary to obtain consistent results, also, where a number of castings are made together in one mould, the best results are obtained by placing the moulds on end for casting, using a downgate extending to below the bottom casting and feeding all the castings in an upward direction. The object is to supply metal progressively from the lower castings to the higher ones, the gates being so arranged that the metal does not splash or enter into a mould until it has reached that level. A very good yield ratio of castings to runners can be obtained by this method of moulding.

To make castings this way using the normal moulding boxes was not economic at this particular foundry, due to lack of suitable equipment, and it was decided to use core-moulds, these to be made on a standard core-making machine used in the core-shop. The advantages to be gained by this method were that the cores could be made by female labour using the standard core-sand mix and dried quickly in a continuous stove; also, by keeping the thickness to a minimum, they were light to handle both in assembly and in transport to and from the drying stove.

Building the Core Box

A metal frame was made with inside dimensions approximately 18 in. by 10 in. by 3 in. deep and fitted to the machine. Eight tapped holes were put in the bottom edge at specified centres, and a number of plates of a suitable size were drilled to the same centres as the tapped holes, to form interchangeable bottoms to the core-box. When it was necessary to use a core 3 in. deep, the patterns and runners were fitted direct to a bottom plate, but where a lesser depth was sufficient, a board of the same dimensions as the inside of the box was first attached to the plate and the pattern fixed on to the board. In this case when the plate is fixed on the core-box frame, the board projects into the box, thereby reducing the depth of the core by the thickness of the board. Changing a plate consists only of taking out and replacing eight screws, so that very little machine time is lost. This arrangement is shown in Fig. 1.

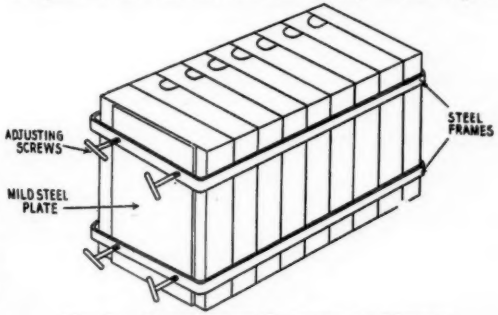


FIG. 2.—ASSEMBLY OF FLAT-BACKED MOULDS.

Whenever possible, flat backed castings are kept together so that the back of one core completes the mould when placed against the face of the next. By using this method, only one core is necessary for each mould except for a plain flat core at one end of each assembly. Where two half-moulds are required to form a complete mould, the method of setting these together correctly is by arranging for three half spherical recesses, 1 in. diameter, to be formed in the face of each half, and a 1 in. diameter ball bearing is placed in each recess when assembling.

Core-Moulds for Stainless Steel Castings

Assembly and Casting

The cores are assembled by stacking a number of moulds, clamping together, then turning the assembly through 90 deg. to the correct position for casting. The clamping equipment was made to hold the number of moulds it was considered convenient to handle in one assembly, and consists of rectangular steel frames with adjusting screws at one end. Two frames are used with each assembly with a mild steel plate at each end of the moulds. Fig. 2 shows an assembly of flat-backed moulds. This method has proved successful and economic, and could be applied to castings in other materials for which dry-sand moulds are necessary.

Book Reviews

The Measurement of Fluid Pressure, by J. R. Fawcett. Published by Emmott & Company, Limited, 31, King Street West, Manchester 3. Price 2s. net.

This is a really practical booklet from which the foundry manager can gain all the essential information he needs for the choice, installation and maintenance of fluid pressure gauges. It is very clearly illustrated with thirty line-diagrams and pictures of instruments.

Speed Control of Electric Motors, by "Engineer-in-Charge." Published by Emmott & Company, Limited, 31, King Street West, Manchester 3, Price 2s. 6d. net.

Unlike many books on this subject, this one carries a minimum of mathematics. The author has relied on a series of very clear diagrams to elucidate his text, and he has been very successful.

Anodic Oxidation of Aluminium and its Alloys. Published by the Aluminium Development Association, 33, Grosvenor Street, London, W.1. Price 1s.

This bulletin is a veritable textbook on the subject of anodising. It runs to 64 pages and is particularly well illustrated. It is logically set out and after an introduction to this essentially British invention, the procedure common to all processes is detailed, followed by methods involving chromic, sulphuric and oxalic acids. After this, there are ten pages covering the dyeing procedure. The book concludes with six extremely useful appendices. For the very modest price asked, this brochure is, indeed, very good value.

Die Energiebriefe des Dr. cal. Sparfleiss. Price 3.75 D.M. Published by Verlag Stahleisen M.B.H., Dusseldorf, 1948.

This is a most interesting book of 168 pages, written in the form of an exchange of semi-humorous letters between a fully qualified fuel efficiency expert and a works' fuel watcher. It is particularly readable, and it is noteworthy to realise that it is possible to convey so much real technical information in such simple language. It is a pity that the book is not available in English, because if it were, a copy could with advantage be placed in the hands of anyone in charge of a power plant, large or small.

J.F.K.

Cast-Iron Pipes for Hydraulic Power

The British Standards Institution has recently published a revision of B.S.44, Cast Iron Pipes for Hydraulic Power. In revising the standard the opportunity has been taken to refer to the new grade of cast iron covered in B.S.1452, which constitutes a combination and revision of B.S.321, Grey Iron Castings, and B.S.786, High-duty Iron Castings. This revised British Standard No. 44 refers to straight pipes, bends, tees and special castings of two classes, for working pressures not exceeding 900 lb. per sq. in. and from 900 to 1,200 lb. per sq. in. respectively. It covers quality of material, mode of casting, freedom from defects, variation of weight, machining, marking, coating, testing and inspection. Tables of dimensions and weights of various types in the two classes are given. Copies of this British Standard can be obtained from the Sales Department, British Standards Institution, 24, Victoria Street, London, S.W.1, at a cost of 3s.

Photographic Exhibition

The 93rd Annual Exhibition of Photography will be held by the Royal Photographic Society this Autumn at 16, Princes Gate, London, S.W.7. It is to be divided into two sections:—Pictorial and Colour, September 10 to October 3, and Scientific, Nature, Record, and Technical, October 9 to 30; all dates inclusive. For this year's exhibition 5,600 entries were received, of which nearly 700 have been accepted, representing work from all over the world.

House Organs

Wiggin Nickel Alloys—July. Published by Henry Wiggin & Company, Limited, Grosvenor House, Park Lane, London, W.1.

This issue contains several articles of interest to foundrymen, of which one on high nickel alloy castings is outstanding. Other subjects dealt with are elecric cookers, pickling tank tie rods, marine shafting and de-icing systems. All are well illustrated. Copies are available to our readers who write to the Park Lane office.

Albion Works Bulletin, Vol. 2, No. 7. The House Organ of John Harper & Company, Limited, Willenhall.

Because a Birmingham newspaper carried an adverse criticism of the foundry industry, this company persuaded the Editor to print a picture of their foundry. In another local newspaper, there was a picture of three generations of the Holmes family—all moulders. This constitutes very good publicity for the industry, and the details are all given in this bulletin.

T. B. WORTH will deliver a lecture to the Institution of Production Engineers entitled "The Education of the Production Engineer" at the Assembly Hall, The Royal Empire Society, Northumberland Avenue, London, W.C.2, at 7 p.m. on September 9.

The Machine Tool and Engineering Exhibition

In his speech at the opening of the Machine Tool and Engineering Exhibition last week the Minister of Supply, Rt. Hon. G. R. Strauss, P.C., M.P., gave an answer to critics of the policy of exporting tools by his statement that it was necessary to export some tools to buy food and that the position was continually under review. Furthermore, he said that, as a long-term policy for betterment of world conditions, the helping of other countries to prosperity by supplying them with tools was a "boomerang" policy which would also bring us prosperity. Those were possibly the most contentious statements in his address, in which he quoted figures for the size and value of the exhibition as a collection of machinery covering 200,000 sq. ft. of space and worth over £3 million. To-day, he said, the output of new metal-working machines would exceed £30 million in value per year, as compared with 1935, when it was £6½ million. In conclusion, he reviewed the spheres of activity of various government departments and manufacturers' associations and congratulated the Machine Tool industry on its achievements.

"Castings" versus "Weldings"

It was thought that an exhibition such as that now running at Olympia would throw some light on the trend of events in the competition which is said to be going on in the machine tool industry with regard to the adoption of weldings to replace castings in the assembly of quite large machines. It was found, however, by our representative, that no clear-cut indications could be found. There was, it is true, a number of machine builders who were convinced that weldings had come to stay and, in their own organisation, had become perhaps more favoured (though they were always careful to qualify their remarks by stipulating "normalising of a welded frame before machining" or "for such-and-such a type of machine only"). American- and Belgian-built machines also indicated no definite trends. By and large there were more castings on view than ever before and for more diverse applications. In a few cases light alloy castings had replaced iron and steel, but in the main the adaptability of castings to design and to give pleasing lines, as well as the inherent damping capacity of cast iron and its rigidity, were fully recognised.

Surface Finish

As regards surface finish of the castings, most makes of machinery looked so sleek and smooth that one was forced to conclude they had been specially "dressed up." Some manufacturers, however, exhibited notices to the effect that this was not the case, and as the appearance of their castings was similar to that of the general run, it seems fair to conclude that, on the average, casting surfaces have improved. So, too, has design. Perhaps the emphasis on streamlining has never been so clearly shown. A lathe, a milling or drilling machine with its knobs and levers and projecting essential features, does not lend itself to streamlining, and yet so much had been done in this direction that the "new look" of the machinery was a major attraction of the show. In the case of colour, there was an almost universal adoption of greys. There were "green" greys and "blue" greys, and dark and ordinary greys, but no other colour. This, it was explained, was not due to a survival of "battleship" conditions but because grey is the colour which is most pleasing and restful to the "eye" under existing factory lighting conditions and fluorescent lighting in particular.

Around the Stands

A glance round the stands revealed much that was of interest quite apart from the fact that this was not a foundry exhibition. Swing grinders and heavy-duty floor grinders of foundry types were shown on the stands of F. E. Rowland & Company, Limited, and Luke & Spencer, Limited. The former also showed an abrasive cutting-off machine and the latter a comprehensive range of grinding wheels. Abrasive wheels were also shown on the stands of Universal Grinding Wheel Company, Limited, Norton Grinding Wheel Company, Limited, and the Carborundum Company, Limited. This last firm also showed crucibles. Almost the whole stand of Wadkin, Limited, was devoted to woodworking machinery suitable for pattern-shop use, and the many model patterns produced on the stand ably demonstrated their efficiency. Also of primary interest to pattern-makers was the stand of Isometric Projections, Limited, where there was demonstrated a drafting machine for producing isometric impressions from "flat" engineering drawings. It is often so difficult to visualise, from an ordinary drawing in the pattern-shop, first, how the job will look "in the solid," and second, how it can be made as a pattern, that an isometric view has much to commend it. On the stand of S. Russell & Sons, Limited, there were on view several models of cold saws and saw sharpening machines. As the strength of cast materials increases from year to year, it becomes more and more difficult to remove runners and risers, and increasing use of such sawing machines becomes necessary.

Service Organisations

Among the stands of the service organisations, the historial section of the Machine Tool Trades' Association contained several old machines from which modern counterparts have developed. The Department of Scientific and Industrial Research, with the N.P.L. and other allied Associations, included demonstrations of accuracy in measuring. In particular, a "Comparator" for checking surface plates was said to be accurate to 0.0001 in. on about 24-in. spans, and embodied a stabilised cast-iron beam as its main component. The stand of the Mond Nickel Company was devoted to explaining the contribution of nickel alloying technology to toolmaking designers and engineers. The Metalock Casting Repair Service showed how high-tensile steel inserts could be fixed stitch-wise in a casting to repair major fractures.

The exhibition, which is open on week-days from 10.30 a.m. to 6.30 p.m., closes on September 11.

Steel Moulding Boxes from Standard Section Channel

By A. V. C. White

Fig. 1 explains in detail the method of manufacture of the steel box parts for foundry use. The mild steel channel can be obtained from the stockholder, already sawn off into lengths, and these are butt jointed by welding inside and outside of the joint. They can either be provided with loose grids or flat mild steel bars across the width of the box made by welding. The joint face of each pair of boxes is lightly skimmed over on the planing machine to ensure perfect flatness. Provision for the pin-holes is made by welding a small pad underneath the flange of the channel, the boxes are then jig drilled and a standard jig bush of the headless type is pressed into position and reamed.

The trunnions are made as follows:—A length of 2½ in. diameter bar is screwed on one end 2 in. British Standard Pipe thread, and at the other end a 4 in. diameter flat blank is welded on to form the lip. The screwed end of the trunnion is then inserted into a 5 in. sq. × ½ in. plate, which has been tapped in the centre, and the two are then welded together. The 5 in. plate is then bolted into position on the box part side, which has previously been drilled to receive it, and a fillet weld is then run between the plate and the channel.

Such boxes are extremely simple to make and may be suitably ribbed where necessary, by using up scrapped pieces of ⅜ in. or ½ in. plate to reinforce the channel. They may be made from channel ranging from 6 in. × 3 in. to 17 in. × 4 in., and in addition to their strength and lightness, are extremely rigid and easily repairable. The channel can be obtained more cheaply than cast steel boxes.

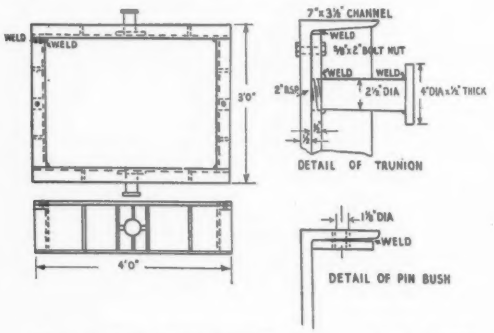


FIG. 1.—BOX PARTS FROM 7 IN. × 3½ IN. MILD STEEL CHANNEL.

FOR THE FIRST TIME in Denmark, demonstrations of radar in action will be given at the Exhibition of British goods to be held in Copenhagen, from September 18 to October 3.

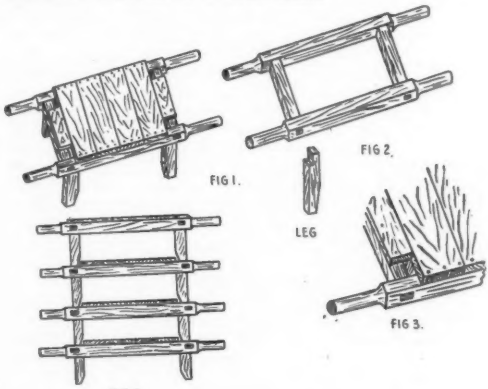
Core Carriers and Temporary Storage of Cores

By "Checker"

The use of some kind of appliance for the temporary storing of cores, which can at the same time be utilised as a core carrier, for quick transportation by hand to other parts of the foundry when the necessity arises, can be found useful on numerous occasions.

A suitable article for this purpose, made entirely from wood, is shown in Fig. 1. This comprises a stout frame, the ends and sides being fixed together by mortise and tenon joints. The side rails are extended beyond the ends, so that they can be used as handles for carrying purposes; for this reason they are shaped to give a more comfortable hand grip (see Fig. 2). Legs are added; these are shouldered back to give the necessary support and are fixed in each corner. The top is covered by timber approximately 1 in. thick, except at the four corners; these portions are left clear so that the carriers can be stacked upon each other to any convenient height, with the legs of the upper carrier resting in these corner slots of the one below, the shoulder which is formed ensures that there is no possibility of their being moved or knocked out of position and falling. Fig. 3 shows a corner slot in detail.

Sizes of these core carriers must, of course, depend on individual requirements, a useful size being 3 ft. by 1 ft. 6 in. for the actual shelf, with the handles extending a further 12 in. each end. Depth of legs could be 10 in to 12 in., but must be sufficient to ensure the cores underneath do not become fouled by the upper carriers when stacked. Fig. 4 gives a view of several carriers assembled together as a core stand.



FIGS. 1-4.—CORE CARRIERS AND STORAGE RACKS.

THE UNIVERSITY OF LONDON have accepted an offer by the Mullard Electronic Products, Limited, of finance for a Readership in Electronics to be mainly concerned with the post-graduate teaching of research.

The Degreasing of Sheets Prior to Enamelling*

By Pierre Tyvaert

Working Temperature

To obtain the maximum of efficiency, the operation of alkali degreasing should be carried out at high temperature—boiling point if possible. This is because the increase in temperature favours the power of emulsification (elimination of mineral oils) and the speed of saponification (elimination of the greasy products of vegetable or animal origin) of the degreasing solution. On the other hand, the hydrolysis of alkaline salts contained in the latter is increased and this corresponds to liberation of the maximum quantity of the free base. Thus, violent movement of the liquid set up by boiling creates, also, a mechanical action conducive to the cleaning of the sheets immersed in the bath.

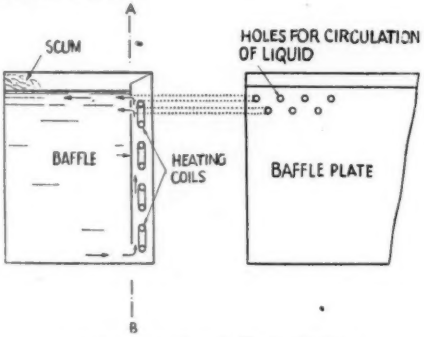


FIG. 1.—VAT FOR DEGREASING.

Degreasing Vats

A simple receptacle of sheet steel can be used for the construction of a degreasing vat, the risks of attack by alkaline solutions being negligible. So far as the heating of this vat is concerned, it would appear that the best method consists in the use of lateral steam heating coils, located behind a screen perforated in the upper part, as shown in Fig. 1.

The convection currents created by such a lay-out favour the degreasing action of the bath. Again, the scum may be drawn towards the opposite wall of the bath, where it floats and can be easily removed (in the morning, for example, before starting work).

Baths for degreasing by immersion by alkaline solutions usually are mixtures of soda, sodium carbonate and trisodium phosphate. There is no universal formula and the composition of the bath should be adapted to the nature of the greasy contamination to be removed. As a guide, the following formula is given:—

		Range
Caustic Soda	gm. per litre 10	10 to 20
Sodium Carbonate	,, ,, 30	—
Trisodium Phosphate	,, ,, 60	50 to 80

Such mixtures are more or less modified according to the nature—often extremely variable—of the grease film and preliminary tests are always carried out with the object of making such adjustments. However, a certain number of proprietary products have, in addition, been tried out for the purpose of solving the problem. They are suitable for users who do not want to make up their own mixtures. These products, made up of a mixture of powders ready to dissolve directly in hot water, frequently carry complementary additions, wetting agents for instance.

Rinsing Vats

A special vat should be available for rinsing the sheets after alkali degreasing. It is necessary to avoid the carrying over of the soluble greasy products or emulsions beyond the rinsing tank after cleaning, as this would create a risk of soiling the metal with little chance of elimination during subsequent drying. To ensure proper rinsing, hot, or better still, boiling, water is advocated. The contents of the vat should be frequently renewed—at least once a day. The perfect method, as used in the States, is the use of hot running water.

Time Required for Alkali Degreasing

The immersion time for the sheets is obviously governed by the nature of the grease to be removed, its quantity and the composition of the degreasing medium. It cannot, therefore, be established *a priori*. Nevertheless, it can be stated that in general the time of degreasing is of the order of 20 to 30 minutes.

*Translated from *Fonderie*.

Scottish Foundry School

The site of the new Scottish Foundry School is at Burnbank, Falkirk. The N.F.S. are giving up part of the premises, and it is proposed that the building on the north-west side of the site should be used ultimately as the moulding shop, etc., after it has been repaired and altered to suit. In order to have the courses started at the beginning of the session, however, it is proposed to utilise another building on the site on a temporary basis as a moulding shop, fitting shop, sheet-metal shop, etc., and lavatories, washhand basins, staffroom and cloakrooms would be provided on the ground floor of that building, and two classrooms and a dining-room upstairs.

It has been suggested that maintenance allowance of 10s. per week be paid to boys who attend to prevocational courses, and that they be granted free travelling expenses and meals, as was granted to boys who attended the County Trades School. With a view to recruiting boys for the foundry school, headmasters of the various schools in the district are to be circularised with particulars of the courses available.

Personal

DR. M. A. VERNON, information officer of the Iron and Steel Institute, has taken a similar post in the Science Department of the British Council.

MR. ALASTAIR MACNEILL WEIR has been appointed secretary of the London Committee of the Scottish Council (Development and Industry).

THE RIGHT HON. THE VISCOUNT RIDLEY has joined the board of Head, Wrightson & Company, Limited, engineers and founders, of Thornaby-on-Tees.

MR. DONALD SKIFFINGTON, a director of John Brown & Company, Limited, shipbuilders, etc., of Clydebank, leaves this month for a trip to New Zealand.

MR. JOHN LAMB, technical manager of the Anglo-Saxon Petroleum Company, Limited, has been appointed to take charge of the company's marine research and development.

MR. HUGH COULSDON, of the heavy-foundry department of the Carron Company, Falkirk, has received a presentation on the occasion of his retirement after 50 years' service with the company.

MR. WILLIAM MCCULLOCH, foreman of G. & J. Weir, Limited, founders, of Glasgow, has retired after 36 years' service with the company. He is an Associate Member of the Institute of British Foundrymen and was awarded the Institute's Diploma in 1929 for his Paper on Monel metal castings.

MR. THOMAS B. BURROWS, of Clarke, Chapman & Company, Limited, ironfounders, boilermakers, etc., of Gateshead, and a past-president of the Newcastle-upon-Tyne branch of the Institute of British Foundrymen, has been appointed foundry manager of the Tees Side Bridge & Engineering Works, Limited, Middlesbrough.

MR. L. C. HORSLEY has retired from his position as an executive director of Ransomes, Sims & Jefferies, Limited, engineers and ironfounders, etc., of Ipswich. He will remain a member of the board. He joined the firm in 1899. Mr. Horsley was appointed cashier in 1907 and 10 years later he became secretary of the company, joining the board in 1939.

SIR FREDERICK BAIN, president of the F.B.I. and deputy chairman of Imperial Chemical Industries, Limited, SIR PETER BENNETT, chairman of Joseph Lucas, Limited, and a member of the Motor Industry Advisory Council, SIR MAURICE DENNY, chairman of William Denny & Bros., Limited, shipbuilders, of Dumbarton, and a member of the executive board of the Shipbuilding Conference, and SIR GREVILLE MAGINNESS, chairman and managing director of the Churchill Machine Tool Company, Limited, joint deputy chairman of Tube Investments, Limited, and a member of the Engineering Advisory Council, are among those nominated by the F.B.I. as members of the Anglo-American productivity council.

Wills

WESTLEY, THOMAS, brassfounder, of Dudley, Worcs ...	£19,280
HARTLEY, WILLIAM, a director of Hartley's Malleable Fittings Company, Limited, Halifax	£9,663
SMALLMAN, P. J. J., for 20 years foundry foreman of W. H. Dorman & Company, Limited, Stafford ...	£1,581

Continuous Casting of Steel

Experiments in America

Experiments have been progressing for some time in America in an attempt to produce steel by continuous-casting methods. Continuous casting entails pouring steel from the open-hearth or electric furnace, possibly *via* a ladle, through a simple water-cooled mould from which it emerges at the bottom as a continuous solid steel bar. In the system just announced by the Republic Steel Corporation of Cleveland and the Babcock & Wilcox Tube Company, New York, the bar then proceeds through an insulated chamber for controlled cooling, while an oxy-acetylene torch cuts it off into required lengths. Experiments in America started six years ago. Chief problems appear to be in disposing of slag, cooling evenly and avoiding explosions.

Britain has also been carrying out research on this project for some time. Work has been proceeding at the Physics Laboratories of the British Iron and Steel Research Association, and, it is believed, at one or two steel companies. The process is not likely to affect the production of large quantities of mild steel for a number of years, as it will have to be considerably developed to compete with cogging mills, etc., for rate of production. Its advantages at the moment appear to rest in the production of small tonnages of alloy steels, improvement in quality, reduction of waste and elimination of equipment required for multiple casting.

No Steel for Pakistan

Although he came to Britain prepared to buy 250,000 tons of steel, after a week of negotiation he had got none at all, declared Mr. Ghulam Ali Allana, President of the Muslim Chamber of Commerce, in London on August 23. The Board of Trade said that supplies were short and it had commitments to other countries, while the British Iron and Steel Federation said they were so much tied down by Government regulations that they had no discretion left to give steel. It seemed that the steel position for Pakistan was more satisfactory in America than Britain, said Mr. Allana. America was letting them have 40,000 tons a year, and shipment had already started.

Mr. Allana met Board of Trade officials again on August 24 in an attempt to get some British steel before he left for Karachi.

AN OVERALL INCREASE of 5 per cent. in shipbuilding steel supplies will be made in 1949 and there will be a small improvement in allocations later this year, said Mr. Charles Murdoch, chairman of the Scottish Board for Industry, in Glasgow, last week. The Office for Economic Affairs had given this assurance in reply to the Board's representations on behalf of the Clydeside and East of Scotland shipbuilders, he said. He made it clear that the Admiralty, in order to establish parity in allocations throughout the United Kingdom, would continue not to show any differentiation between firms or areas.

Iron and Steel Prices Increased

Due to Dearer Coal

Under the Control of Iron and Steel (No. 66) Order, 1948, which came into force on August 23, certain iron and steel prices have been amended (see the JOURNAL, August 26). Basic pig-iron has been raised in price by 2s. 6d., foundry iron by 3s., and heavy finished steel by 3s. 6d. Semi-finished steel of ordinary quality is unchanged. The increases are stated to be, in the main, a reflection of part of the recent rises in the price of coal. The following are the amended maximum prices, per ton, delivered to buyer.

PIG-IRON

Basic:—Delivered station or siding, all districts, £9 10s.

Hematite:—Silicon up to 3 per cent., S. & P., over 0.03 per cent., but not exceeding 0.05 per cent., delivered station or siding to:—N.-E. Coast and N.-W. Coast of England, £10 7s. 6d.; Scotland, £10 14s.; Sheffield, £11; Birmingham, £11 6s.; Wales (Welsh produced iron), £10 7s. 6d.

Foundry and Forge—Delivered station or siding:—No. 3 Iron, Class 2:—Middlesbrough, £9 16s. 9d.; Birmingham, £9 15s. 3d.

Phosphorus over 0.10 per cent. up to 0.75 per cent., Birmingham, £10 2s. 6d.

Staffordshire blast-furnace low-phosphorus foundry iron (0.1 per cent. to 0.5 per cent. phosphorus, and up to 3 per cent. silicon):—South Zone, *i.e.*, all districts south of a line drawn between King's Lynn, Cambridge, Gloucester, and Carmarthen, and including those towns, £12 5s.; North Zone, *i.e.*, all districts north of the South Zone, £12 2s. 6d.; Scotch No. 3 foundry iron, delivered Grangemouth, £10 0s. 5d.

Cylinder and Refined:—South Zone, £12 0s. 6d.; North Zone, £11 18s.

Refined Malleable:—Phosphorus 0.1 per cent. maximum:—South Zone, £12 10s. 6d.; North Zone, £12 8s.

Cold Blast:—South Staffordshire, £15 6s.

Blast-furnace Ferro-managanese:—Standard grade, 78 per cent. Mn, delivered station or siding, £23 13s. 3d.

Spiegeleisen:—20 per cent. Mn, delivered station or siding, £14 7s. 3d.

BILLETS, BLOOMS AND SLABS FOR RE-ROLLING

Basic:—Silico manganese, £21 7s. 6d.

Siemens Martin Acid:—Silico manganese, £21 7s. 6d.

BILLETS, BLOOMS AND SLABS FOR FORGING, DROP-FORGING AND STAMPING

Acid:—Silico manganese, £22 5s.

ALLOY STEELS

Billets:—2-in. up to and including 10-in.:—0.6/1 per cent. nickel, £22 10s. 6d.; nickel chrome (Ni 2.75/3.75 per cent., Cr 0.60/1.25 per cent.), £31: nickel chrome molybdenum (Ni 2.75/3.75 per cent., Cr 0.60/1.25 per cent., Mo 0.20/0.60 per cent.), £37 10s. 9d.

HEAVY STEEL PRODUCTS:—Delivered customer's nearest railway terminus or by water alongside wharf except where otherwise provided for in the Deposited Schedules:—

N.-E. Coast, Northern Joint Area, Scotland, Belfast shipyards; and shipbuilders at Thorne, New Holland, and Gainsborough:—Joists, sections, and bars (angle basis), £17 16s. 6d.; plates, £18 11s. 6d.; boiler plates, £19 9s.

Leeds and district, Midland Area, and South Wales:—Joists, etc., £17 16s. 6d.; plates, £18 14s.; boiler plates, £19 11s. 6d.

Southern Joint Area:—Joists, etc., £17 19s.; plates, £18 16s. 6d.; boiler plates, £19 14s.

F.o.q. Belfast (other than shipyards):—Joists, etc., £18 1s. 6d.; plates, £18 16s. 6d.; boiler plates, £19 14s.

Medium Plates, i.e., *under* $\frac{3}{16}$*-in. thick*:—All deliveries:—Weighing 6 lb. or more per sq. ft., £21 6s.; weighing less than 6 lb., but not less than 4.81 lb. per sq. ft., £21 16s.

Chequered Plates—Delivered to:—N.-E. Coast, and shipbuilders at Thorne, New Holland, and Gainsborough, £20 1s. 6d.; Northern Joint Area, Scotland, Leeds and district, Midlands, South Wales, and Southern Joint Area, £20 4s.

RAILS, FISHPLATES, AND SOLEPLATES

Heavy Rails, i.e., 40 *lb. per yd. and over*:—60 lb. per yd. and over, f.o.t. makers' works, £16 16s. 6d.

Fishplates (for rails 60 lb. per yd. and over), f.o.t. makers' works, £22 6s. 6d.

Soleplates (for rails 60 lb. per yd. and over), f.o.t. makers' works, £20 16s. 6d.

COLLIERY ARCHES AND ACCESSORIES; PIT PROPS

Arches as above, but without fishplates and bolts by 2½-in., single radius, straight or horse-shoe or splayed legs, with one fishplate joint, complete with one pair of fishplates and the necessary bolts and nuts, £20 11s. 6d.

Arches as above, but without fishplates and bolts and nuts, £20 4s. 6d.

Fishplates (for arches) alone, £27 4s. 6d.

Plain Cambered Girders:—4-in. by 2½-in. by 2-in. and 4-in. by 2½-in. by 2½-in., with minimum camber of 2-in. in centre, for use underground only, £19 19s. 6d.

Corrugated Straps; Roofing or Benk Bars, £19 1s.

Copies of the Order (S.I. 1948 No. 1913) may be obtained from H.M. Stationery Office, Kingsway, London, W.C.2, or through any bookseller, price 1d.

Sheepbridge Company's Engineering Activities

Speaking at the annual general meeting of the Sheepbridge Coal & Iron Company, Limited (now the Sheepbridge Company, Limited), Lord Aberconway, the chairman, said that every endeavour was being made to increase the output of engineering products both from their own works and from the works of the Sheepbridge Stokes Centrifugal Castings Company, Limited, and its subsidiaries. Such products formed an increasingly important part of the company's turnover. The monthly output of the products of the group in practically every branch exceeded that for the corresponding previous period.

With a view to the segregation of the engineering side of the company's activities from the production of iron, the Dunston Iron Company, Limited, a fully-owned subsidiary, has been registered.

News in Brief

TIPTREE FOUNDRY COMPANY, Colchester, Essex, has been granted a licence to secure supplies of pig-iron for the production of ploughshares.

A CARGO OF 6,400 tons of scrap from Singapore, the remains of petrol storage tanks bombed both by the Japanese and the Allies, has arrived at Swansea for a local steelworks.

UNION LEAD WORKS, LIMITED, is being wound up voluntarily. Mr. A. M. C. Smith, Martins Bank Chambers, Tyrrel Street, Bradford, is the liquidator. All creditors will be paid in full.

PERMISSION TO EXTEND its factory at Corstorphine, at a cost of £50,000, has been granted by Edinburgh Dean of Guild Court to James H. Lamont & Company, Limited, engineers and brassfounders.

UNITED STATES fourth-quarter mill quotas to domestic consumers of steel sheets and strip are expected to be cut by 5 to 10 per cent. in order to make room for increased voluntary allocations.

ROSYTH WORKMEN produced their " biggest-ever " iron casting at the Dockyard Foundry on August 20. The casting is to form the base of a 7-ton steam hammer, and 28 tons of iron were poured into the mould.

UNDER THE Export of Goods (Control) (Amendment) (No. 5) Order, 1948, which came into force yesterday (Wednesday), an export licence is now required for cobalt. Copies of the Order (S.I. 1948 No. 1929) can be obtained from H.M. Stationery Office, Kingsway, London, W.C.2, or through any bookseller, price 1d.

PIG-IRON IMPORTS into Eire in June were 231 tons, valued at £4,393, compared with 45 tons (£658) in June, 1947. Imports of iron bars and rods totalled 34 tons, valued at £1,348, against 48 tons (£1,530), while 1,489 tons of steel bars and rods, valued at £53,925, against 1,360 tons (£42,617), and 505 tons of iron and steel squares and flats, valued at £21,059, against 427 tons (£12,727), were imported during the month.

WELLWORTHY PISTON RINGS, LIMITED, Lymington, Hants, has concluded a licensing agreement with the Fairchild Engine & Airplane Corporation, New York, covering the use of Fairchild's Al-Fin process for bonding aluminium to iron, steel and other metals. Wellworthy Piston Rings receives an exclusive licence in the United Kingdom to manufacture and sell bonded bimetallic products under Al-Fin process patents, and to sub-license the process to other manufacturers.

AN ARTICLE in the monthly journal of the National Union of Manufacturers states that the productive efforts of British firms are being undermined by the impossibility of replacing plant and machinery to anything like the extent essential in a highly-competitive world. The taxation level, it is claimed, rules out the building-up of reserves for replacement. The Union is collecting data so that a detailed and reasoned case can be put before the Chancellor of the Exchequer.

Whitehead Iron & Steel Company

Modernisation Programme for Subsidiaries

Mr. G. H. Latham, chairman and managing director of the Whitehead Iron & Steel Company, Limited, referred at the company's annual general meeting to the progress of the modernisation programme of its subsidiaries. He said that by the end of the year they hoped to have completed stage I of the programme for Whitehead Hill & Company, Limited, Cwmbran, Mon. This included the installation of high-speed wire-drawing machines, oil-fired rod baker and an annealing plant, all of the most modern design.

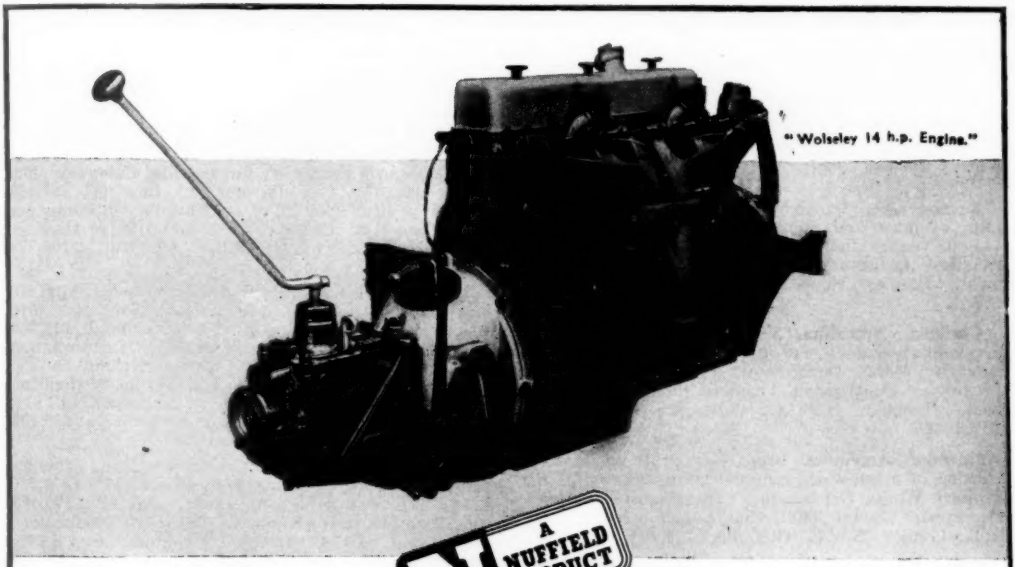
Stating that these works were pioneers in introducing electro-galvanised wire, Mr. Latham said that between 1925 and 1948 much progress had been made and to-day the quality of their galvanised wire was accepted both in this country and abroad as of a very high standard. Scientific investigations carried out on a large scale and conduced by a Government department had confirmed this. Consequently, the demand for the product had increased far beyond the capacity of existing plant, and they were now engaged in putting in additional plant embodying all modifications which had been found advantageous in previous machines. When the scheme was completed, they hoped to double their present output of electro-galvanised wire.

With regard to W. A. Baker & Company, Limited, Newport, Mon, Mr. Latham said they had now completely abandoned the older method of melting steel by crucibles, and had recently brought into operation new high-frequency electrical smelting furnaces. Already they were obtaining considerable economy in production, better quality, and a larger range of steel castings. They had also installed further modern machine tools in the machine shop, but were handicapped in getting full production from this unit by the shortage of skilled machine operators. Mr. Latham added that he had anticipated in his last report that the mechanised foundry would have been in operation by now, but there had been a long delay in obtaining the necessary structural steelwork for the building, with a consequent delay in the completion of the foundry. He thought it was fairly certain that it should be in production during the autumn.

Scrap from Germany

As the result of the recommendations of the Scrap Investigation Committee set up last March by the Ministry of Supply, a large number of cranes and other equipment has been made available for scrap operations in Germany. This is stated in the 10th report from the Select Committee on Estimates, which adds that shipments of scrap are now approaching 80,000 tons a month, and may in the course of the next few months rise to 100,000 tons a month.

Lt.-Gen. Sir Kenneth Loch, who was a member of the investigation committee, has been appointed scrap co-ordinating officer in Germany. He will be concerned with obtaining commercial as well as booty scrap, and will work in close co-ordination with the Ministry of Supply.



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FOR ALL HIGH-DUTY
ENGINEERING CASTINGS

THE STANTON IRONWORKS COMPANY LIMITED, Nr. NOTTINGHAM

Contracts Open

The dates given are the latest on which tenders will be accepted. The addresses are those from which forms of tender may be obtained.

Argentina, September 17—Provision and erection of mechanical equipment for a sewage disposal plant at Ezeiza. The Export Promotion Department (Room 1086), Thames House North, Millbank, London, S.W.1.

Buenos Aires, September 29—Supply of 170 metric tons of super duralumin and aluminium alloy in various shapes and sizes (No. 212/48), for the Aerotechnical Institute. The Export Promotion Department, Thames House North, Millbank, London, S.W.1.

Cordoba, Argentina, September 15—Meters, temperature indicators and other instruments, for the Sanitary Works Department. Room 1095, Export Promotion Department, Thames House North, Millbank, London, S.W.1. (Reference No. E.P.D. 39562/48).

Palermo, Argentina, September 7—Provision and erection of a hot-water central heating system, for the Sanitary Works Department. The Export Promotion Department (Room 3088), Thames House North, Millbank, London, S.W.1. (Reference, E.P.D. 39621/48).

Pewsey, September 13—Construction of 9-in. and 6-in. stoneware and cast-iron sewers, etc., for the Rural District Council. A. P. I. Cotterell & Son, engineers, 54, Victoria Street, Westminster, London, S.W.1. (Fee £3 3s., returnable.)

Towcester, September 9—Construction of 4-in. asbestos-cement/spun-iron mains, for the Rural District Council. Howard Humphreys & Sons, consulting engineers, 17, Victoria Street, Westminster, London, S.W.1.

Tredegar, September 20—Supply of cast-iron mains and special connections, for the Urban District Council. The Gas Engineer and Manager, Gas Department, Poplar Road, Tredegar, Mon.

Vigo, Spain—Two mobile rubber-tyred cranes and two tractors for haulage and shunting, for the Port Authorities. The Export Promotion Department, Board of Trade, Thames House North, Millbank, London, S.W.1. (Reference, E.P.D. 39321/48).

Changes of Name

The following companies have recently changed their names, the new titles being given in parentheses:—

INTERNATIONAL METALS, LIMITED, London, W.C.2 (Montclare & James, Limited).

SHEEPBRIDGE COAL & IRON COMPANY, LIMITED, Chesterfield (Sheepbridge Company, Limited).

UNI-FOLD MACHINERY COMPANY, LIMITED, London, W.1 (Uni-Fold Mailing Machinery, Limited).

Company News

(Figures for previous year in brackets.)

Follsain Metals—Trading profit for 1947, £11,971 (£7,301); net profit after depreciation, etc., but before taxation, £9,787 (£4,510); taxation, £7,668; to share of costs of merger scheme with Wycliffe Foundry & Engineering, £725; forward, £10,622 (£9,228).

Brightside Foundry & Engineering Company—Net profit, after tax, for the year to June 30, £85,429 (£87,481); final dividend of 1s. 9d., plus 9d. bonus per share (same); to reserve, £10,119 (£11,519); to plant replacement, £25,000 (£30,000); forward, £106,373 (£114,960).

Manley & Regulus—Profit for year ended April 30 (excluding subsidiaries), £102,090 (£89,045); tax provision in previous years no longer required, £15,000 (nil); to tax, £51,431 (£44,320); exceptional depreciation written off plant, etc., £5,106 (nil); dividend on 7% preference shares, net, £770 (same); ordinary dividend of 15% (same) and bonus of 10% (same), £17,534; deferred repairs, nil (£10,000); general reserve, £35,238 (nil); forward, £74,477 (£67,466).

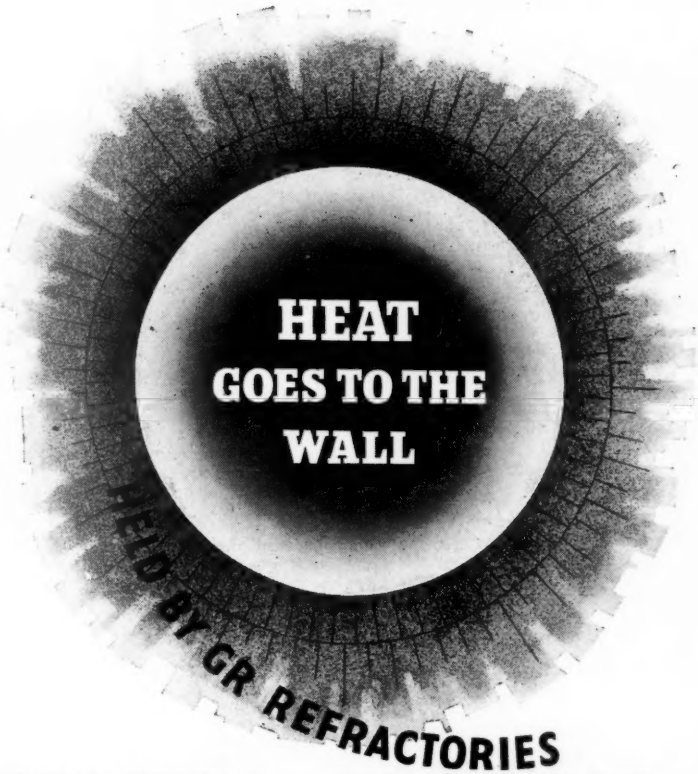
Wolverhampton Metal Company—Group trading profits for the year ended March 31, £274,750 (£150,219); sundry other income, making £275,482 (£155,056); to depreciation, £7,037 (£4,616); directors' emoluments, £6,287 (£5,117); auditors' fees, £525 (£400); loan interest, nil (£892); employees' service fund, nil (£1,000); profits tax, £35,500 (£52,000); leaving £226,133 (£91,031); to income tax, £105,000 (£46,000); written off goodwill, £3,472 (nil); employees' past service pension scheme, £20,000 (nil); reserve against fall in metals, £20,000 (nil); dividend equalisation, £10,000 (£5,000); general reserve, £11.399 (nil); final dividend of 20% on larger capital (15% and bonus of 10%), making 40% (same); forward, £65,445 (£43,008).

Aluminium Castings' Loan Replacement

In his statement with the accounts to March 31, Mr. R. K. Calder, chairman of the Aluminium Castings Company, Limited, Greenock, states that the directors of the company intend to take the "earliest possible steps" to replace loans with further permanent finance. The loans were obtained by the company following the refusal of the Capital Issues Committee last year to sanction the issue of 150,000 preferred ordinary shares for which provisional arrangements had been made.

The loan arrangements, which were provided on the basis that repayment would not be required before 1952, have recently been consolidated and the company now has at call £200,000, in addition to the sum of £100,000 already drawn.

THE DIRECTORS OF Ruston & Hornsby, Limited, engineers, boilermakers, etc., of Lincoln, announce that the recent issue of 410,000 ordinary £1 shares at 50s. a share on a one-for-four basis to the company's ordinary stockholders has been over-subscribed.



And well held by refractories of high uniform excellence which can be depended upon to provide strong, stable and lasting furnace linings. To support a range of products so wide that it covers the requirements of all types of furnaces, G.R. technical experience is available to users in order to assist in the selection of a suitable refractory for any particular application. When you specify 'GR' you enjoy a double service — a dependable product and knowledgeable assistance. That's why it pays to consult G.R.

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Raw Material Markets

Iron and Steel

The end of the summer finds blast-furnace men more favourably placed in regard to raw materials. Good stocks of imported ore have been accumulated and, though not excessive, deliveries of coke are on a fairly satisfactory scale. It is hoped very shortly to bring at least one more blast furnace into operation; the whole of the current output is promptly going into consumption. The foundry trade, though still handicapped by the labour shortage, is keyed up for a big production drive in the closing months of the year, and its success will be largely dependent on the extent of the deliveries of pig-iron and scrap. Cast-iron scrap is in constant demand, and few establishments are receiving all the pig-iron they need. Hematite and refined iron are relatively more plentiful than low- and medium-phosphorus grades, but common foundry iron is scarce, with the result that the light-castings trade is operating on a hand-to-mouth basis.

The announcement of special arrangements with Belgian producers for the shipment of an additional 100,000 tons of steel will be specially welcomed by the re-rolling industry, whose operations throughout the year have been hampered by inadequate deliveries of steel semis. Until the slow-down of operations for the holidays, deliveries of billets, sheet bars, slabs, etc., had consistently fallen short of requirements, and although the position has been temporarily eased by the arrival of supplies while the mills were idle, these small accumulations will be speedily absorbed. All the light mills have an impressive volume of orders in hand and are in urgent need of sheet bars and small square and round billets.

The call for plates and sections, sustained at a very high level, enables the mills to arrange their programmes without frequent changes of the rolls and thereby accelerates production. The demand for supplies is unabated, but the high rate of deliveries which has been maintained throughout the year must, to some extent, have mitigated the difficulties of the steel users. Shipbuilders miss no opportunity of emphasising the need for more material, but there are many competing claims for finished steel products. Sheet mills are more overloaded with orders than any other branch of the finished-steel trade, and there is little abatement in the call for colliery material.

Non-ferrous Metals

While in the United States activity in non-ferrous metals continues unabated, conditions in the United Kingdom are rather dull, and on the Continent, too, demand has dropped to a low level. Much of the trouble in the Continental countries seems to be due to lack of currency, for there is no reason to suppose that the gap in requirements created by the war years has been bridged as yet. Prices are firm, of necessity, for the world has to follow the lead given by the U.S., where the demand for stockpiling is insistent. One of the conditions attaching to European acceptance of Marshall aid is that the recipient countries shall give every assistance in providing, so far as possible, strategic materials required by America for building up reserves. Among these is copper, of which America is already importing some 30,000 tons monthly, and, presumably, any sterling metal not required by the British Government would also cross the Atlantic.

In this connection, the possibility of surplus copper from Rhodesia becoming available does not seem to be out of the question. It is generally understood that the Ministry of Supply is arranging forward cover at the rate of at least 30,000 tons per month, and it seems doubtful whether U.K. users will need as much during the second half of the year. The July figure is not yet available, but can be estimated at not much more than 25,000 tons, and probably August will be no better, perhaps less. Both these months have suffered from interruptions by holidays and consumption is bound to decrease in consequence. It is possible, therefore, that there might be a considerable surplus by the year-end and unless the Government intends to follow the American example and build up a strategic stock, a decision to place this unwanted tonnage at the disposal of the United States might be reached.

At the time of writing no price changes have been announced in this country, and the British consumer continues to acquire metal well below the world price. But if the difference is being made up from the taxpayer's pocket there is little consolation in enjoying such a favoured position. The market is naturally at a loss to understand the position, but the Ministry of Supply continues to preserve complete silence. The only solution seems to be to follow world prices as closely as possible, charging the user more as the price rises and passing on quickly the benefit of any fall in values.

Special Purchase of Belgian Steel

100,000 *Tons for U.K.*

In order to make a contribution to the easing of trade barriers between participating countries of the Organisation for European Economic Co-operation, the Government has decided to make a special purchase of 100,000 tons of steel from Belgium and Luxemburg during the coming three months. Under the present financial arrangements between the United Kingdom and other countries, this purchase may involve Britain in a loss of gold, and the continuation of such purchases must, therefore, depend upon the institution of a payments scheme between the participating countries, which will facilitate trade exchanges.

When O.E.E.C. was considering the import programmes of the participating countries for the third quarter of this year, it emerged that Belgium and Luxemburg would have a certain surplus quantity of steel available for export in this quarter which, however, other countries were unwilling to buy from them for currency reasons. The Belgian and Luxemburg industries are now making a special effort to provide within the 100,000 tons the kind of products which the U.K. particularly needs. The purchase is in addition to the quantities of steel being obtained by the U.K. from Belgium and Luxemburg under current trade agreements.